DOCUMENT RESUME

ED 195 406 SE 033 389

AUTHOR Ekman, John E.
TITLE Groundwater and Distribution Workbook.
INSTITUTION Wisconsin Vocational, Technical and Adult Educational Services, Madison. District Consortium.
SPONS AGENCY Department of Health, Education, and Welfare, Washington, D.C.: Environmental Protection Agency, Washington, D. C.
PUB DATE Jun 80
NOTE 263p.

EDRS PRICE MF01/PC11 Plus Postage.
DESCRIPTORS Earth Science: Postsecondary Education: Public Health: *Public Service Occupations: Science Education: *Technical Education: Technical Occupations: *Utilities: *Water Resources
IDENTIFIERS *Ground Water: Water Distribution: Water Quality: Water Supply: *Water Works Operators

ABSTRACT

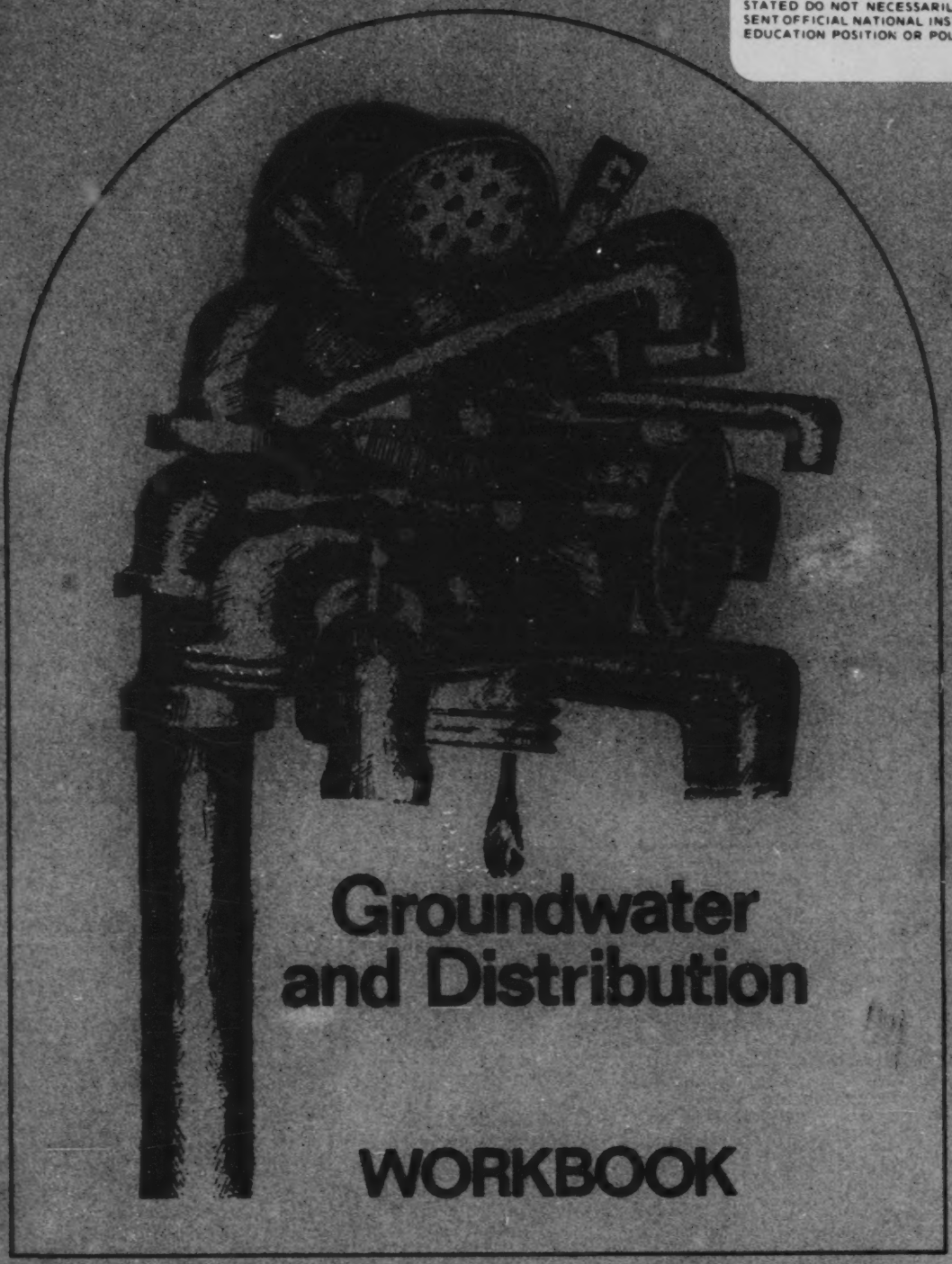
Presented is a student manual designed for the Wisconsin Vocational, Technical and Adult Education Groundwater and Distribution Training Course. This program introduces waterworks operators-in-training to basic skills and knowledge required for the operation of a groundwater distribution waterworks facility. Arranged according to the general order of water flow through a water supply facility, workbook topics are offered in a competency-based modular format. Each module contains six sections: (1) introduction, (2) objectives, (3) learning activities, (4) worksheets, (5) student self-check, and (6) final checkout. Recommended learning materials to be used in conjunction with this workbook include textbooks, films, slides, a video tape, maps, and pamphlets. Taken together, each student's final checkouts comprise an individual progress record which can be used to identify achievement of course objectives. (Author/WB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 075406

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY



Groundwater and Distribution

WORKBOOK

WISCONSIN BOARD OF VOCATIONAL, TECHNICAL AND ADULT EDUCATION

SE 033 389

GROUNDWATER AND DISTRIBUTION WORKBOOK

John E. Ekman
Project Specialist

Wisconsin Vocational, Technical and Adult Educational Services
District Consortium
310 North Midvale Boulevard
Madison, Wisconsin

June 1980

This workbook was developed pursuant to a grant with the Wisconsin Board of Vocational, Technical and Adult Education, through use of federal funds from the Department of Health, Education and Welfare and the Environmental Protection Agency. The views or opinions herein are those representing the professional judgment of the author and do not necessarily reflect the views of the participating agencies.

ACKNOWLEDGEMENTS

The author wishes to thank all those individuals who have contributed to the successful completion of this workbook.

Special thanks are extended to Jim Kohl, Operator Instructor, Wisconsin Department of Natural Resources, and Sandra Carman.

Much appreciation is also extended to the members of the Wisconsin VTAE Water-Wastewater Advisory Committee for their support and guidance during the development of this workbook.

Cover design by Jerry Anderson.

TABLE OF CONTENTS

	Page
Acknowledgements	i
Table of Contents	ii
Preface	iii
Resources	iv
Regulations (Certification)	1
Regulations (Safe Drinking Water Act)	12
Regulations (Wisconsin Public Service Commission)	29
Hydrologic Cycle	42
Groundwater and Geology	53
Well Construction	68
Pumps	86
Water Chemistry	107
Chemical Addition	123
Chemical Feed Equipment	139
Bacteriology	158
Laboratory Testing	170
Waterworks Math	180
Distribution Systems	194
Meters	223
Cross Connections	237
Safety	246

PREFACE

The "Groundwater and Distribution Workbook" is a sequence of topics in groundwater, basic water treatment, and water distribution. The workbook is designed to be used in conjunction with the Wisconsin VTAE Groundwater and Distribution Training Course and selected American Water Works Association (AWWA) texts to help introductory waterworks operators grasp basic skills and knowledge required for day-to-day operation of a groundwater-distribution waterworks facility. Operators may also find the workbook helpful in preparing for Wisconsin DNR Groundwater and/or Distribution certification examinations.

Each topic in the workbook is presented in a competency-based instruction (CBI) modular format. The modules are arranged according to the general order of water flow. The CBI format has been utilized because it lends itself well to establishing behavorial objectives around "need to know" information. Hence, the student will know what is expected of him/her at the outset of the module, leaving the learning outcomes fixed and time the variable.

Each module is broken down into six sections: introduction, objectives, learning activities, worksheet, student self-check, and final checkout. The introduction for each module provides a brief overview of the topic. A number of objectives are then listed. The objectives correspond to the important points of the module and identify the skills the student should have mastered upon completing the module. The student should utilize the resources listed in the learning activities section to accomplish the objectives. A worksheet has been provided in each module to assist the student in fulfilling the objectives. The student is encouraged to use a variety of learning activities to complete each item on the worksheet, including video and printed material, hands-on work, or discussion with co-participants. A self-check exercise is included after the worksheet to help the student identify whether s/he accomplished the objectives of the module. Student self-check questions should be answered without the aid of books, worksheets, or co-participants. For participants who have been out of school awhile, the student self-check section should also help familiarize you with and give you some experience in taking multiple-choice examinations similar to those encountered in certification testing. The final checkout is essentially a restatement of the objectives. For those final checkout items checked no, the student should spend a little more time reviewing these to meet the goals of the module. All of the final checkouts taken together comprise an individual progress record which can be used to identify the student's achievement of course objectives.

RESOURCES

Textbooks:

Ground Water, AWWA Manual M21, American Water Works Association.

Basic Water Treatment Operator's Manual, AWWA Manual M18, American Water Works Association.

A Training Course in Water Distribution, AWWA Manual M8, American Water Works Association.

Films:

Groundwater: The Hidden Reservoir, John Wiley and Sons, Inc.

Deep Waters, Layne-Western Company, Inc.

The Safe Handling of Chlorine, PPG Industries, Inc.

Is Your Drinking Water Safe?, Modern Talking Picture Service, Inc.

Water Follies, Stan Phillips and Associates.

Water, Water Everywhere . . . , American Water Works Association.

Slide Series:

The MF Test for Total Coliform, Millipore Corporation.

Modern Water Distribution Systems, American Water Works Association, Wisconsin Section.

Well Construction, Wisconsin Department of Natural Resources (DNR).

Groundwater, Instructor's Personal Collection.

Video Tape:

Fire Hydrant Maintenance, Madison Water Utility.

Pamphlets:

Why Water Works, American Water Works Association.

Vertical Turbine Pumps for Water Wells, Layne-Northwest, Division Layne-Western Co., Inc.

Lineshaft Turbine Pumps, Jacuzzi Brothers, Inc.

Chlorine Safe Handling, PPG Industries, Inc.

Pamphlets (continued): Fluoridation, Wisconsin Department of Health and Social Services.

Excavating and Trenching Operations, U. S. Department of Labor Occupational Safety and Health Administration.

A Guide for the Installation of Ductile Iron Pipe, Cast Iron Pipe Research Association.

50 Cross Connection Questions, Answers, and Illustrations, Watts Regulator Company.

Codes: NR 114, Wisconsin Administrative Code Book.

NR 109, Wisconsin Administrative Code Book.

NR 111, Wisconsin Administrative Code Book.

PSC 185, Wisconsin Administrative Code Book.

Maps: Wisconsin Glacial Deposits, University of Wisconsin - Extension, Geological and Natural History Survey.

Bedrock Geology of Wisconsin, University of Wisconsin - Extension, Geological and Natural History Survey.

REGULATIONS (CERTIFICATION)

Introduction:

New water quality criteria mandated by the 1974 Safe Drinking Water Act, the discovery of waterborne carcinogens, and an increased public awareness have resulted in the need for more highly skilled waterworks operators. In order to assure that operators have the needed skills, the Wisconsin Department of Natural Resources (DNR) carries out an operator certification program as required by Chapter NR 114, Wisconsin Administrative Code. This module covers the certification requirements of NR 114 as they pertain to waterworks operators.

Objectives:

1. DEFINE the following terms as they are used in Chapter NR 114, Wisconsin Administrative Code: waterworks, municipal water system, community water system, public water supply system, certified operator, experience, direct responsible charge.

2. NAME and DEFINE the six waterworks classes.

3. LIST the two grades of waterworks operator and DIFFERENTIATE between them.

4. Given hypothetical data, correctly IDENTIFY the classification of and the grade of operator needed for given utility.

5. IDENTIFY the classification of and the grade of operator needed for your waterworks according to NR 114.

6. LIST the qualifications you must possess in order to be the certified operator in charge of your waterworks.

7. STATE the requirements of NR 114 with respect to: examinations, number of operators who must be certified at each public water system, number of days prior to the examination an application must be filed with the DNR, the fees for certification examination and certificate renewal, the passing score on a certification examination, review of exam papers.

Objectives (continued):

8. DESCRIBE the requirements for renewal of a certificate.
9. DESCRIBE the procedure for reinstatement of lapsed certification.
10. IDENTIFY the six grounds for revocation of certification.
11. COMPLETE sample certificate-examination application form.

Learning Activities:

1. LISTEN to certification presentation.
2. READ Chapter NR 114 of the Wisconsin Administrative Code.
3. COMPLETE Worksheet.
4. COMPLETE sample certificate-examination application form provided by Instructor.
5. COMPLETE Student Self-check and CHECK answers.
6. PROCEED to Final Checkout.

WORKSHEET

1. Define the following terms as they are used in NR 114:

   waterworks _____

   _____

   municipal water system _____

   _____

   community water system _____

   _____

   public water supply system _____

   _____

   certified waterworks operator _____

   _____

   direct responsible charge _____

   _____

   experience _____

   _____

2. The waterworks classification scheme is broken down into six classes. Name and define each class.

   (1) _____: _____

   _____

   (2) _____: _____

   _____

   (3) _____: _____

   _____

(4) _____: _____

_____

(5) _____: _____

_____

(6) _____: _____

_____

3. List the two grades of waterworks operator and differentiate between them.

_____

_____

_____

_____

_____

4. The Rickert Water Utility has five wells with a sixth well under construction. The Utility has a seven zone distribution system with one elevated storage tank and one ground storage reservoir. Well Number Three contains a six cell pressure filter for removing iron by oxidation and filtration. What is the classification of the Rickert Water Utility? (Note: Classification is based upon the sum of all applicable classes.)

_____

_____

5. What grade of operator is needed for the Rickert Water Utility?

_____

6. State the classification of your waterworks. (Note: Classification is based upon the sum of all applicable classes.)

_____

_____

7. What grade of operator is needed for your waterworks?

_____

_____

8. List three qualifications you must possess in order to be the certified operator in charge of your waterworks.

(1) _____

_____

(2) _____

_____

(3) _____

_____

9. List the qualifications you must possess in order to be an operator in training.

_____

_____

_____

10. What is the application fee for a Grade 1 waterworks Class D certification-examination?

_____

11. How many times annually are written examinations conducted?

_____

12. How are practical (on site) examinations arranged?

_____

_____

13. Applications for a certification examination must be received by the DNR central office at least _____ days before the date of examination.

14. A score of _____ percent or greater is considered passing on a certification examination.

15. Under what conditions may an applicant for a certification examination review his/her examination?

_____

_____

_____

16. Certificates must be renewed every _____ year(s). The renewal fee is $_____.

17. List the two methods by which a waterworks operator may review his/her certificate.

(1) _____

_____

(2) _____

_____

18. If your certificate has lapsed for more than 180 days, you may be reinstated by doing three things. They are:

(1) _____

(2) _____

(3) _____

19. If an operator chooses not to do the three things listed in Question #18, is there another method of reinstatement? If so, describe it.

_____

_____

_____

20. List the six grounds for revocation of a certificate.

(1) _____

(2) _____

(3) _____

(4) _____

(5) _____

(6) _____

STUDENT SELF-CHECK

___ 1. An applicant must file an application with the Department of Natural Resources at least _____ days prior to the date of the examination?

a. 3
b. 9
c. 15
d. an application is not required to take the examination

___ 2. Which of the following are required to become certified as a Grade 1 D operator? (Indicate all correct responses.)

a. one year experience operating a waterworks utilizing a distribution system
b. successful completion of written distribution examination
c. two years experience combined with passing a written examination
d. successful completion of practical distribution examination
e. with more than five years experience, no examination is required

___ 3. Practical examinations for operator certification are arranged on an individual basis, while written certification examinations are conducted how many times annually?

a. 2
b. 4
c. 12
d. written exams are also arranged individually

___ 4. A waterworks operator in training may operate a waterworks for a period not to exceed:

a. 1 month
b. 6 months
c. one year
d. under no circumstances may an operator in training operate a waterworks

___ 5. The fee for a waterworks application-exam-certificate is _____. (This fee must accompany the application form.)

a. $.50
b. $5
c. $10
d. $25

____ 6. Operator certification requirements are found in:

a. Wisconsin Administrative Code, Chapter RN 021
b. Wisconsin Administrative Code, Chapter NR 114
c. State Register
d. EPA Manual M21

____ 7. The waterworks classification scheme is broken down into six classes. A Class G waterworks is a:

a. a good waterworks
b. a waterworks utilizing surface water
c. a government-owned waterworks
d. a waterworks utilizing groundwater

____ 8. Waterworks certificates are issued for a(n) _____ period.

a. 2 year
b. 1 year
c. 6 month
d. indefinite

____ 9. An operator whose certificate has not been renewed within 180 days of the expiration date may be reinstated by:

a. paying all back renewal fees
b. fulfilling the continuing education requirements for the lapsed period
c. paying a $5.00 penalty fee
d. both b and c above
e. a, b, and c above

____ 10. One of the renewal requirements for a waterworks certificate is that operators must attend at least _____ of approved training every two years.

a. 6 hours
b. 12 hours
c. 24 hours
d. 40 hours

____ 11. Which of the following are grounds for revocation of a waterworks operator's certificate:

a. falsified operating records submitted to the Department of Natural Resources
b. showed inability to operate his/her plant
c. falsified information on certificate application form
d. all of the above
e. only a and c above

____ 12. Passing score for a certificate examination is:

a. 50%
b. 70%
c. 75%
d. none of the above

____ 13. The operator in charge of a distribution waterworks facility must possess:

a. operator in training Class M-1 certificate
b. Grade 1 Class S certificate
c. Grade 1 Class D certificate
d. operator in training Class F certificate

Directions for Questions #14 through #16: MATCH the definition with the correct term.

____ 14. community water system

____ 15. municipal water system

____ 16. public water system

KEY

a. a system for the provision to the public of piped water for human consumption, if such system has at least fifteen service connections or regularly serves an average of at least twenty-five individuals daily at least sixty days out of the year. Such term includes (1) any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system, and (2) any collection or pretreatment storage facilities not under such control which are used primarily in connection with such system.

b. a public water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents.

c. community water system owned by a county, city, village town, sanitary district, utility district, or public institution.

ANSWERS TO STUDENT SELF-CHECK

1.	c	9.	e
2.	a, b, d	10.	b
3.	b	11.	d
4.	c	12.	c
5.	b	13.	c
6.	b	14.	b
7.	d	15.	c
8.	a	16.	a

FINAL CHECKOUT

		YES	NO
1.	Defined given terms as used in Chapter NR 114.	___	___
2.	Named and defined the six classes of waterworks.	___	___
3.	Listed the two grades of waterworks operator and explained the differences between them.	___	___
4.	Identified the classification of and the grade of operator needed for hypothetical utility.	___	___
5.	Identified the classification of and the grade of operator needed for own waterworks.	___	___
6.	Listed qualifications to be the certified operator in charge of own waterworks.	___	___
7.	Explained the procedure for becoming a certified operator.	___	___
8.	Stated requirements of NR 114 for given parameters.	___	___
9.	Described requirements for certificate renewal.	___	___
10.	Described procedure for reinstatement of lapsed certification.	___	___
11.	Identified grounds for revocation of certification.	___	___
12.	Completed the sample certificate-exam application.	___	___

REGULATIONS (SAFE DRINKING WATER ACT)

Introduction:

Americans have come to realize that clean water is essential for not only our physical health and general well being, but also for our national economic welfare. Clean water is necessary for drinking water, agricultural and industrial uses, commercial and residential development, recreational use, and for a healthier environment. To protect public health and safeguard public water supplies, Congress passed the Safe Drinking Water Act (Public Law 93-523) and President Ford signed it into law on December 14, 1974. The Act directs the U. S. Environmental Protection Agency (E.P.A.) to establish national drinking water standards on substances sometimes found in drinking water. Most public water systems, including those in Wisconsin, already meet the established standards. For these systems, the new safe drinking water program is simply added insurance that the quality of water supplied will be maintained or improved. But for systems that cannot always provide high quality drinking water, the Act will require some changes. Although E.P.A. is responsible for establishing national regulations under the Act, each state may assume primary enforcement authority over the regulations. Wisconsin has assumed primary enforcement authority and implementation of the regulations is accomplished through Chapter NR 109, Wisconsin Administrative Code. This module covers the requirements established in NR 109, along with other water quality criteria found in NR 108 and NR 111.

Objectives:

1. DEFINE the following terms as they are used in NR 109: contaminant, maximum contaminant level, community water system, non-community water system.
2. CITE examples of community and non-community water systems.
3. DIFFERENTIATE between "primary" and "secondary" drinking water standards.
4. IDENTIFY the maximum contaminant levels for given inorganic chemicals.
5. STATE when public notification is required in relation to contaminant levels.

Objectives (continued):

6. DESCRIBE means of public notification when required in relation to contaminant levels.

7. IDENTIFY the maximum contaminant level for total trihalomethane compounds.

8. STATE the effective dates and monitoring requirements for total trihalomethane compounds in regard to community population.

9. SHOW how to determine the minimum number of monthly bacteriological samples to submit to the State Laboratory of Hygiene.

10. DETERMINE the number of bacteriological samples your waterworks must submit each month.

11. DESCRIBE a good bacteriological sampling program.

12. IDENTIFY laboratories where bacteriological samples may be analyzed.

13. IDENTIFY maximum allowable microbiological contaminant levels.

14. EXPLAIN what an operator should do when a bacti sample report comes back "unsafe."

15. DESCRIBE the required means of public notification for microbiological contamination in emergency and non-emergency situations.

16. IDENTIFY secondary standards for given chemicals.

17. DESCRIBE sampling requirements in regard to secondary standards.

18. SPECIFY how often an operator must test for fluoride in the system if fluoride is being added to the water.

19. IDENTIFY type of bottle to be used in collecting a fluoride sample.

20. STATE how often samples must be sent to the State Laboratory of Hygiene for fluoride analysis.

21. IDENTIFY the range fluoride should be maintained between if an operator is adding fluoride.

Objectives (continued):

22. STATE how often an operator must test the chlorine residual in a groundwater-distribution system if chlorine is being added.

23. SPECIFY the free or combined chlorine residual concentration that must be maintained throughout the system if a groundwater source is chlorinating.

24. INDICATE how often bacteriological samples should be collected from a well if the water is chlorinated.

25. STATE how many bacteriological samples must be collected after a reservoir has been cleaned or repaired before it is put back into service.

26. DIFFERENTIATE between a variance and an exemption.

27. GIVE two reasons a variance may be granted.

28. LIST three reasons an exemption may be granted.

29. Given hypothetical data, correctly COMPLETE Form 3300-1, "Monthly Report on Pumpage, Chemical Addition and Water Levels."

30. EXPLAIN what should be done with the original and copies of Form 3300-1 after it is filled out.

31. Given hypothetical data, correctly COMPLETE a bacti form.

Learning Activities:

1. LISTEN to presentation on Safe Drinking Water Act.

2. READ Chapter NR 109, Wisconsin Administrative Code.

3. LOCATE and SKIM Chapter NR 111, Wisconsin Administrative Code.

4. COMPLETE Worksheet.

5. FILL OUT Department of Natural Resources Form 3300-1 and bacti form, using data provided.

6. COMPLETE Student Self-check and CHECK answers.

7. PROCEED to Final Checkout.

WORKSHEET

1. Define the following terms as they are used in NR 109:

contaminant _____

_____

maximum contaminant level _____

_____

community water system _____

_____

non-community water system _____

_____

2. List two examples each of community and non-community water systems:

Community	Non-Community
_____	_____
_____	_____

3. Differentiate between "primary" and "secondary" drinking water standards in relation to health and aesthetic limits.

4. Identify the maximum contaminant levels allowable under NR 109 for the following elements and compounds.

arsenic _____	mercury _____
barium _____	nitrate (as N) _____
cadmium _____	selenium _____
fluoride _____	silver _____
lead _____	sodium _____

5. Analysis of the inorganic chemicals listed above must be completed by June 24, 1980, and be repeated at three-year intervals for all groundwater systems (except those with exemptions). TRUE or FALSE?

6. Public notification is required in dealing with maximum contamination levels for inorganic chemicals when:

   (1) _____

   _____

   (2) _____

   _____

7. The required means of public notification in regard to maximum contaminant levels for inorganic chemicals when a non-emergency (no imminent hazard to public health) exists is:

8. The required means of public notification in regard to maximum contaminant levels for inorganic chemicals when an imminent hazard to public health exists is:

9. What is the maximum contaminant level (MCL) for total trihalomethanes (TTHMS) in ppb and mg/l.

   ppb _____

   mg/l _____

10. State the effective date for total trihalomethane MCL's for community systems serving more than 75,000 people and community systems serving between 10,000 and 75,000 people.

    75,000 _____

    10,000 - 75,000 _____

11. What are the monitoring frequency requirements for total trihalomethane compounds for community systems serving between 10,000 and 75,000 and community systems serving more than 75,000.

    75,000 _____

    10,000 - 75,000 _____

12. The number of bacteriological samples to be submitted to the State Laboratory of Hygiene each month is in direct relation to the _____ of the community.

13. Using the table found in NR 109.31 (2) (a), determine the minimum number of bacteriological samples the following community water systems must submit each month:

Community	Population	Number of Samples
a	200,200	_____
b	4,500	_____
c	1,420,000	_____
d	25,250	_____

14. Determine the minimum number of bacteriological samples your water works must submit each month.

15. List three points in a good bacteriological sampling program.

(1) _____

_____

(2) _____

_____

(3) _____

_____

16. Bacteriological water samples may be analyzed at the:

_____

or _____

_____

17. Using the membrane filtration method, the maximum microbiological contaminant level is:

_____

_____

18. Identify the section and subsection of NR 109 in which the fermentation tube (MPN) maximum microbiological level is stated.

19. If a bacteriological sample report comes back "unsafe" from the State Laboratory of Hygiene (exceeds the maximum contaminant level set in NR 109), an operator should:

20. If a bacteriological check sample comes back "unsafe" from the State Laboratory of Hygiene, an operator should:

(1) _____

_____

(2) _____

_____

(3) _____

_____

21. Describe the required means of public notification for microbiological contamination in non-emergency (no imminent hazard to public health) and emergency situations (imminent hazard to public health).

22. Identify the secondary inorganic chemical standards found in NR 109 for the following elements and compounds:

chloride _____

copper _____

hydrogen sulfide _____

iron _____

manganese _____

total residue _____

23. When is a waterworks operator required to monitor for compliance with secondary standards?

24. If fluoride is being added to public water supply, an operator must test the fluoride concentration from the distribution system at least _____

_____

25. What type of bottle should be used to collect a fluoride sample?

26. If fluoride is being added to the public water supply, how often must sample(s) be sent to the State Laboratory of Hygiene for fluoride analysis?

27. The Dental Health Section of the Department of Health and Social Services recommends that the fluoride concentration be maintained between _____ mg/l and _____ mg/l for drinking water.

28. If a groundwater distribution system is adding chlorine, an operator should check the residual chlorine concentration how many times a week from a representative point in the distribution system?

29. Groundwater suppliers who are chlorinating should maintain at least a _____ mg/l free residual or a _____ mg/l combined chlorine residual concentration in the distribution system.

30. Bacteriological samples should be collected how many times a year from a well if the water is chlorinated?

31. The required number of bacteriological samples to be collected after a reservoir has been cleaned or repaired before it is put back into service is?

32. Differentiate between a variance and an exemption. (Hint: See note under Part V, NR 109.)

33. Give two reasons why a variance may be issued.

(1) _____

(2) _____

34. List three reasons why an exemption may be granted.

(1) _____

(2) _____

(3) _____

35. Complete a bacti form (provided by Instructor) for the distribution sample described in the following:

Operator Larry Mass collected a bacti sample on February 22, 1979, at 2:00 p.m. from the smooth bore faucet in room 201 of the city court house, 1234 Main Street to submit for his weekly distribution sample.

Larry works for the Merrian Waterworks, 36th Avenue North, Webster, Wisconsin, 99911. The waterworks continuously chlorinates, maintaining a .2 mg/l free chlorine residual.

36. Operator Larry Mass collected the following data during the month of March, 1978, from Well #1. Record this information along with his address (from Question #35) on Form 3300-1 (provided by Instructor).

Date	Gallons Pumped
March 1	37,000,000
2	39,500,000
3	40,000,000
4	31,250,000
5	38,300,000
6	50,560,000
7	34,600,000
8	44,000,000
9	48,500,000
10	51,000,000

Static water level on 3/1 - 133 ft. Pumping water level on 3/1 - 156 ft.
Static water level on 3/7 - 133 ft. Pumping water level on 3/7 - 155 ft.

37. Explain what should be done with the original and copies of Form 3300-1, "Monthly Report on Pumpage, Chemical Addition and Water Levels," after it is filled out.

30

STUDENT SELF-CHECK

____ 1. "Primary drinking water standards" relate to one's health while "secondary drinking water standards" relate to the aesthetic quality of water. TRUE or FALSE?

____ 2. Bacteriological samples should be collected at least once every six months from a well if the water is chlorinated. TRUE or FALSE?

____ 3. A fluoride sample must be collected in a bottle that contains sodium thiosulfate. TRUE or FALSE?

____ 4. Bacteriological samples may be analyzed at the State Laboratory of Hygiene or at a laboratory certified by the Department of Health and Social Services. TRUE or FALSE?

____ 5. The minimum number of bacteriological samples to be submitted for coliform analysis is determined by:

a. community's elected officials
b. geographic area
c. length of distribution line
d. population
e. none of the above

____ 6. An operator is required to test the concentration of _____ at least once a day from a representative point in the distribution system.

a. fluoride
b. chlorine
c. iron
d. manganese

____ 7. The Dental Health Section of the Department of Health and Social Services recommends that the fluoride concentration for drinking water be maintained between _____ mg/l and _____ mg/l.

a. 0.1/0.5
b. 1.0/1.5
c. 1.0/5.0
d. 1.0/10.0

____ 8. A variance from a maximum contaminant level may be granted because:

a. it will not result in an unreasonable risk to the health of the people served by the system
b. application of the best technology cannot meet the requirement
c. neither of the above
d. both of the above

____ 9. If a groundwater supply is chlorinating, the operator is required to test the chlorine concentration from a representative point in the distribution system at least _____.

a. daily
b. twice a week
c. once a week
d. once every two weeks

____ 10. The secondary standard for manganese in a public water supply is:

a. .5 ppm
b. .3 ppm
c. .1 ppm
d. .05 ppm

____ 11. "The required means of public notification for a violation of a MCL that does not pose an imminent hazard to public health is _____."

a. newspaper advertisement
b. news release to radio station
c. door to door contact
d. inclusion of notice in next set of water bills provided bills are issued on a quarterly basis (if bills are issued less frequently than quarterly, then by written notice within three months)

____ 12. Groundwater suppliers who are chlorinating, are required to maintain at least a _____ mg/l free residual or a _____ mg/l combined chlorine residual in the distribution system.

a. .01/.05
b. 0.1/0.3
c. 0.1/0.5
d. 1.0/1.5

32

____ 13. Upon notification that a bacti sample collected from the distribution system in accordance with the monthly bacti sampling program is unsafe, an operator must:

a. notify the public immediately
b. collect a "check" sample from the same point within 48 hours
c. continue regular sampling program
d. flush the system with chlorine

____ 14. All of the following are examples of community water systems except:

a. municipal water utilities
b. mobile home parks
c. restaurants
d. condominiums

ANSWERS TO STUDENT SELF-CHECK

1.	TRUE	8.	d
2.	FALSE	9.	b
3.	FALSE	10.	d
4.	TRUE	11.	d
5.	d	12.	c
6.	a	13.	b
7.	b	14.	c

FINAL CHECK-OUT

		YES	NO
1.	Defined given terms found in NR 109.	___	___
2.	Listed examples of community and non-community water systems.	___	___
3.	Differentiated between "primary" and "secondary" drinking water standards.	___	___
4.	Identified maximum allowable contaminant levels for given inorganic chemicals.	___	___
5.	Stated when public notification is required in relation to contaminant levels.	___	___
6.	Described means of public notification when it is required.	___	___
7.	Identified MCL for TTHM compounds.	___	___
8.	Stated effective dates and monitoring requirements, for TTHM's in regard to community populations.	___	___
9.	Showed how to determine the minimum number of monthly bacteriological samples to submit to the State Laboratory of Hygiene.	___	___
10.	Determined the number of bacteriological samples your own waterworks must submit each month.	___	___
11.	Described a good bacteriological sampling program.	___	___

		YES	NO
12.	Identified laboratories where bacteriological samples may be analyzed.	___	___
13.	Identified maximum allowable microbiological contaminant levels.	___	___
14.	Explained what should be done when a bacti sample comes back "unsafe."	___	___
15.	Described the required means of public notification for microbiological contamination in emergency and non-emergency situations.	___	___
16.	Identified secondary standards for given chemicals.	___	___
17.	Described sampling requirements in regard to secondary standards.	___	___
18.	Specified how often an operator must test for fluoride in the system if fluoride is being added to the water.	___	___
19.	Identified type of sample bottle to be used in collecting fluoride sample.	___	___
20.	Stated how often a sample must be sent to the State Laboratory of Hygiene for fluoride analysis.	___	___
21.	Identified the range fluoride should be maintained between, if adding fluoride.	___	___
22.	Stated how often operator must test chlorine residual in a groundwater-distribution system if chlorine is being added.	___	___
23.	Specified the free or combined chlorine residual concentration that must be maintained throughout the system if a groundwater source is chlorinating.	___	___
24.	Indicated how often bacteriological samples should be collected from a well if the water is chlorinated.	___	___
25.	Stated how many bacteriological samples must be taken after a reservoir has been cleaned or repaired before it is put back into service.	___	___
26.	Differentiated between variance and exemption.	___	___
27.	Gave two reasons a variance may be granted.	___	___
28.	Listed three reasons an exemption may be granted.	___	___

	YES	NO
29. Given hypothetical data, correctly completed Form 3300-1, "Monthly Report on Pumpage, Chemical Addition and Water Levels."	___	___
30. Explained what should be done with the original and copies of Form 3300-1.	___	___
31. Given hypothetical data, correctly completed a bacti form.	___	___

REGULATIONS (PUBLIC SERVICE COMMISSION)

Introduction:

Through its Public Service Commission (PSC), the State of Wisconsin has regulated private and municipally owned utilities for over 70 years. The mission of the Public Service Commission is to "supervise and regulate every public utility in Wisconsin to the end that reasonably adequate service and facilities are available at rates that are reasonable and just." In light of this, standards for public utility water service were established. These standards are found in the Wisconsin Administrative Code, Chapter PSC 185. This module introduces PSC 185 and discusses its provisions as they relate to a waterworks operator.

Objectives:

1. IDENTIFY who must observe the rules and requirements set forth in PSC 185.

2. DESCRIBE the construction standards of PSC 185 for mains and service pipes.

3. EXPLAIN the role of the PSC in establishing water rates.

4. SUMMARIZE the provisions of PSC 185 with respect to:

   a. general requirements
   b. free or discriminatory service
   c. information available to customers
   d. metered service
   e. meters
   f. jumper meter settings
   g. remote reading devices
   h. water bills
   i. disconnection and refusal standards
   j. pressure standards
   k. flushing mains
   l. valves and hydrants
   m. thawing frozen services
   n. records

5. IDENTIFY the location in your facility of the following records: maps showing location and physical characteristics of utility; pumpage records; pressure records; meter test records.

Learning Activities:

1. LISTEN to presentation on the Public Service Commission.

2. READ Chapter PSC 185, Wisconsin Administrative Code, ("Standards for Water Public Utility Service").

3. COMPLETE Worksheet.

4. COMPLETE Student Self-check and CHECK answers.

5. PROCEED to Final Checkout.

WORKSHEET

1. Who must observe and follow the rules and requirements set forth in PSC 185?

2. List the five points under main construction standards (PSC 185.52) and explain each in your own words.

   (1) _____: _____

   (2) _____: _____

   (3) _____: _____

   (4) _____: _____

   (5) _____: _____

3. The following points deal with construction standards for service pipes. Summarize the requirements of PSC 185 with respect to each.

size _____

depth _____

inspection _____

4. Does your utility have any exemptions or local ordinances which vary from the PSC main construction or service pipe standards? If so, what are they?

5. What is the role of the PSC in establishing water rates?

6. In your own words, explain the "general requirement" (185.13).

7. Describe the provisions of PSC 185 regarding free or discriminating service.

8. What information does the PSC require you make available to customers?

   (1)

   (2)

   (3)

   (4)

   (5)

9. What are the requirements of PSC 185 in regard to metered service?

10. For those uses which are not required to be metered, identify and explain the procedure used to determine the amount of water used.

_____

_____

_____

_____

11. Customers meters must be tested before use, at the request, upon customer complaint, and periodically to insure accuracy. The periodical test interval (in years) for the following size meters are:

Size	Test Interval (years)
5/8"	_____
1"	_____
2"	_____
6"	_____

12. Describe the alternate sample testing plan for "before use" tests for 5/8", 3/4" and 1" meters.

_____

_____

_____

13. For each of the following meters, identify the type of test flows which must be run to determine percent registration.

Type		Type of Test Flow
Positive displacement:	(1)	_____
	(2)	_____
Compound:	(1)	_____
	(2)	_____
	(3)	_____
Current meters:	(1)	_____
	(2)	_____

14. Identify the minimum test flow and the normal test flow limits for the following positive displacement meters.

Meter Size	Minimum Test Flow (gpm)	Normal Test Flow Limits (gpm)
5/8"	_____	_____
1"	_____	_____

15. Positive displacement meters shall register between _____ and _____ percent within the range of normal test flow limits before being placed into service.

16. Identify the section and subsection of PSC 185 where the test flow limits for compound meters are found.

17. Current meters should register between _____ and _____ percent throughout the range of normal test flow. Current meters should also register at least _____ percent the minimum test flow.

18. The minimum meter testing equipment for a facility with less than 250 meters is:

_____

_____

and for a facility with greater than 250 meters, it is:

_____

_____

19. When must remote meter registers be tested?

_____

_____

20. What is involved in testing a remote reader?

_____

_____

_____

21. What does the PSC say about jumpering meter settings?

_____

_____

_____

22. List six items which should be recorded on a water bill and/or customer receipt:

_____ _____

_____ _____

_____ _____

23. Using rates established for your utility, calculate a resident's bill and an industrial bill using information for your community.

Residential Industrial

24. List four reasons utility service may be disconnected or refused.

(1) _____

(2) _____

(3) _____

(4) _____

25. List four reasons utility service may <u>not</u> be disconnected or refused.

(1) _____

(2) _____

(3) _____

(4) _____

26. Describe the procedure for disconnection or refusal of utility service.

27. What are the minimum pressure standards for the following conditions:

Condition	Standard (psi)
fire flow	_____
static	_____

28. What are the normal operating pressures for your utility?

_____

29. What is the recommended maximum residual pressure for a utility?

_____

30. How often must dead end mains be flushed?

_____

_____

_____

31. To assure that valves and hydrants are operable, they should be checked and tested once every _____ years.

32. State the conditions whereby a utility is not held responsible for thawing frozen services.

_____

_____

_____

_____

_____

_____

33. List the records the PSC requires you (the operator) to keep and the length of time you must retain them.

	Records	Length of Time Retained
(1)		
(2)		
(3)		
(4)		
(5)		
(6)		
(7)		
(8)		
(9)		
(10)		
(11)		
(12)		
(13)		

34. Where are the following records found in your waterworks?

(1) map showing location and physical characteristics of utility _____

(2) pumpage records _____

(3) pressure records _____

(4) meter rest records _____

STUDENT SELF-CHECK

____ 1. The utility may supply water for street and sewer flushing free of charge since these are non-municipal uses. TRUE or FALSE?

____ 2. Valves and hydrants should be operated at least once every two years to insure workability when needed. TRUE or FALSE?

____ 3. PSC 185 requires keeping records of customer complaints, pumpage, meter testing, system pressure, and interruptions. TRUE or FALSE?

____ 4. Utility water rates are approved by:

a. Department of Natural Resources
b. Federal Water Act
c. Public Service Commission
d. the municipality

____ 5. Unless negligence has been shown, frozen services are thawed at the expense of:

a. the customer
b. the utility
c. Department of Natural Resources
d. Public Service Commission

____ 6. Meters must be tested:

a. before use
b. periodically to insure accuracy
c. upon request or complaint of customer
d. a and c only
e. a, b, and c

____ 7. Except for water used for construction and street or sewer flushing, all water sold by a utility must be _____ unless otherwise authorized by the Public Service Commission.

a. chemically treated
b. metered
c. tested
d. none of the above

____ 8. The minimum required fire flow pressure is:

a. 10 psi
b. 15 psi
c. 20 psi
d. 35 psi

___ 9. Which of the following are reasons for disconnection or refusal of utility service? (Indicate all correct responses.)

a. diversion of service around the meter
b. failure to pay for a different type or class of utility service
c. failure to pay charges arising from underbilling occurring more than one year prior to the current billing due to faulty metering
d. when a dangerous condition exists

___ 10. Which of the following are included under main construction standards?

a. distribution system shall be laid out in a grid
b. utility shall try to design its distribution system to avoid dead-end mains
c. mains shall be placed at such depth (or otherwise protected) to prevent freezing during the coldest weather experienced by the community
d. valves should be provided at reasonable intervals and at appropriate locations so that repairs or maintenance will interrupt a minimum number of customers
e. all of the above

18

ANSWERS TO STUDENT SELF-CHECK

1. FALSE
2. TRUE
3. TRUE
4. c
5. b
6. e
7. b
8. c
9. a, b
10. e

FINAL CHECKOUT

	YES	NO
1. Identified who must observe the rules and requirements set forth in PSC 185.	___	___
2. Described the construction standards of PSC 185 for mains and service pipes.	___	___
3. Explained the roles of the PSC in establishing water rates.	___	___
4. Summarized the provisions of PSC 185 with respect to given aspects of service.	___	___
5. Identified location in own facility of specified records.	___	___

HYDROLOGIC CYCLE

Introduction:

Water is one of our most vital resources because it is essential for life. In a general sense, water is a renewable resource, unlike fossil fuels or many mineral resources which are exploited at a rate faster than their formation. Water circulates the Earth through the hydrologic cycle; the cycle of precipitation, runoff, and evapotranspiration. The hydrologic cycle is a closed system with no beginning or end. It is from this cycle that our supply of fresh water is continually replenished. Yet with uneven distribution and increasing demands for water, the natural renewal rates of the hydrologic cycle may not keep pace with the demand. Certain areas of the United States are already experiencing spot shortages and may face more serious problems in the future. In order to assure adequate future supplies, water suppliers will have to carefully manage their stock and in some cases augment supplies with non-traditional sources furnished by new technology.

Objectives:

1. EXPLAIN the meaning of "hydrologic cycle" and DEFINE related terms.
2. LIST four forms of precipitation.
3. SKETCH the hydrologic cycle and LABEL all processes.
4. IDENTIFY the forces involved in the hydrologic cycle.
5. DESCRIBE the movement of water through the hydrologic cycle.
6. IDENTIFY residence times for various hydrologic cycle processes.
7. EXPLAIN the meaning of "water budget" as it applies to the hydrologic cycle.
8. Using appropriate tables, ESTABLISH a water budget for Wisconsin and the United States.
9. Using the water budget, IDENTIFY portion available for our use.

Objectives (continued):

10. EXPLAIN why certain areas across the United States are experiencing water shortages.

11. LIST means or methods to help offset shortages.

Learning Activities:

1. LISTEN to presentation on the hydrologic cycle.

2. VIEW film, "Water Follies."

3. READ pages 1-3, AWWA Manual M18 and pages 1-4, AWWA Manual M21.

4. EXAMINE Figure 1, page 5, AWWA Manual M21 and Figure 1.1, page 2, AWWA Manual M18.

5. COMPLETE Worksheet.

6. COMPLETE Student Self-check and CHECK answers.

7. PROCEED to Final Checkout.

WORKSHEET

1. What is the hydrologic cycle?

2. Define the following terms:

evaporation

transpiration

evapotranspiration

condensation

precipitation

vaporization

interception loss

infiltration

runnoff

3. List four forms of precipitation.

(1) _____

(2) _____

(3) _____

(4) _____

4. Sketch the hydrologic cycle, labeling the following processes: precipitation, vaporization, interception loss, infiltration (percolation), runoff, storage, evaporation, transpiration, vapor transportation and condensation.

5. What forces are involved in the hydrologic cycle?

_____

6. Describe, in your own words, the movement of water through the hydrologic cycle.

7. For each of the following, give an average residence time (time water is held in that phase of the cycle):

   atmospheric moisture _____

   soil and subsurface moisture _____

   groundwater _____

   rivers _____

   oceans _____

8. What is a water budget in relation to the hydrologic cycle?

   _____

   _____

9. Using Table 1.2 in Manual M18, establish a water budget for the United States.

10. What portion of the budget is available for our use? How much out of that do we actually use?

    _____

11. Establish a water budget for Wisconsin, identifying what portion is available for our use.

12. Is the distribution of precipitation across the United States even or uneven? If even, state the figure; if uneven, identify the section which receives the most and the section which receives the least (east, central or west).

13. Is the volume of water on the Earth increasing or decreasing?

_____

14. Explain why certain areas in the United Sates are experiencing water shortages.

_____

_____

_____

15. What methods or means are available to help offset or combat these shortages?

_____

_____

_____

_____

_____

STUDENT SELF-CHECK

____ 1. The hydrologic cycle consists of all of the following <u>except</u>:

a. precipitation
b. runoff
c. respiration
d. evaporation

____ 2. Which of the following is <u>not</u> involved in the hydrologic cycle?

a. radiation
b. gravity
c. condensation
d. hydroelectricity

Directions for Questions #3 through #12: <u>MATCH</u> the following terms with their definitions.

____ 3. hydrologic cycle
____ 4. evaporation
____ 5. transpiration
____ 6. evapotranspiration
____ 7. condensation
____ 8. precipitation
____ 9. infiltration
____ 10. interception loss
____ 11. runoff
____ 12. residence time

a. water flowing over the earth's surface into rivers, lakes, and ocean
b. process by which water vapor is lost to the atmosphere from vegetation
c. movement of water into and through the ground
d. process by which water becomes a vapor at a temperature below its boiling point
e. system by which nature circulates water
f. process by which water vapor changes to a liquid
g. water which never reaches the ground but is retained on buildings, trees, shrubs and plants
h. combination of water vapor lost to the atmosphere from vegetation and surface water
i. water falling to the earth from the atmosphere as rain, snow, hail, etc.
j. period water is held in a phase of the cycle

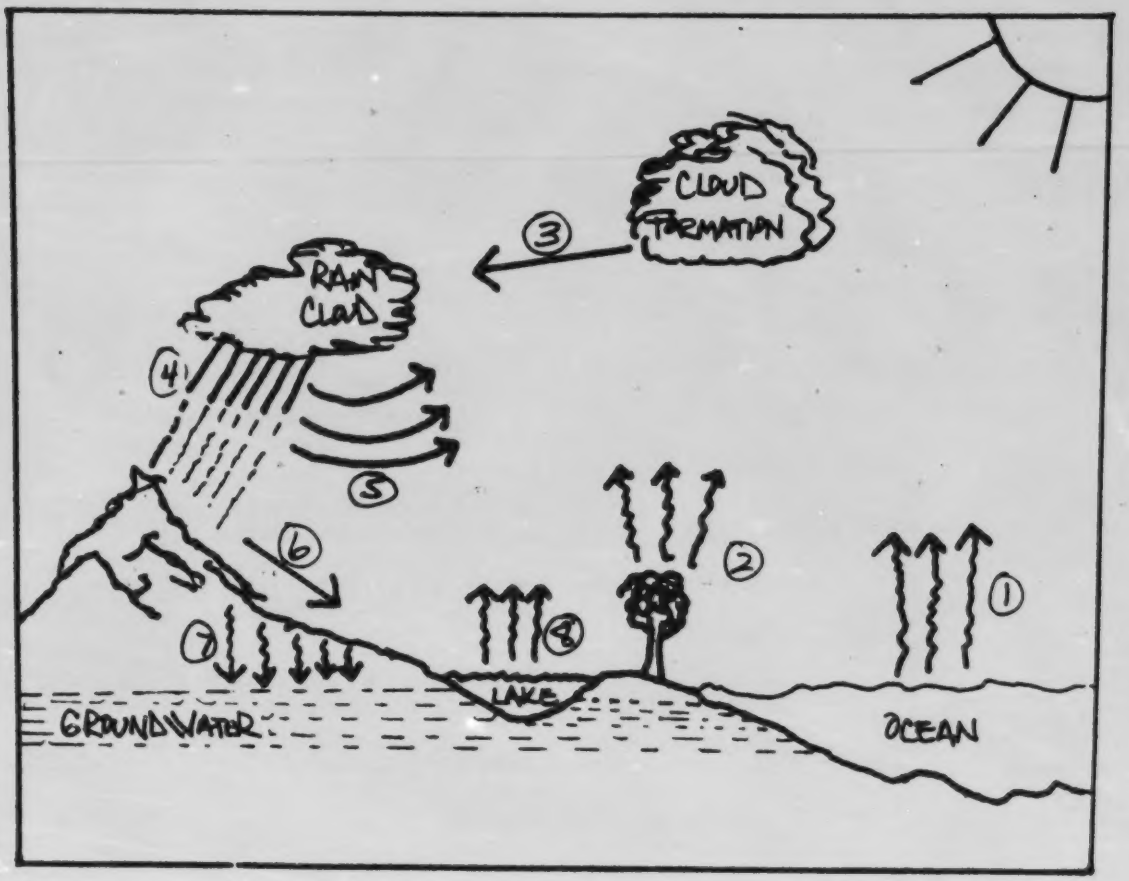
13. In the hydrologic cycle below, identify the numbered processes:

(1) _____ (5) _____

(2) _____ (6) _____

(3) _____ (7) _____

(4) _____ (8) _____



14. From the following list of words, fill in the blanks in the paragraph to describe the hydrologic cycle.

condenses
evaporation
infiltrates
precipitation
rises
runs off
transpiration
vaporizes
evaporates

The sun's energy or radiation _____ water from surface supplies (steams, rivers, lakes, ocean, etc.) into the atmosphere. This water vapor _____ and collects to form clouds. Under certain conditions, this vapor _____ and falls back to the earth as _____. Some water _____ as it falls, while most of it _____ into the ground or _____ over the surface to streams, rivers, lakes and, in turn, back to the oceans. That portion which moves down into the ground may be stored for long periods of time or it may be discharged at springs or seeps. The cycle then repeats, with _____ from surface water and _____ from plants.

15. Uneven distribution of precipitation and increasing demands for water are creating spot shortages in some areas of the country. TRUE or FALSE?

ANSWERS TO STUDENT SELF-CHECK

1. c.
2. d
3. e
4. d
5. b
6. h
7. f
8. i
9. c
10. g
11. a
12. j

13. (1) evaporation
    (2) transpiration
    (3) condensation
    (4) precipitation
    (5) vaporization
    (6) runoff
    (7) infiltration
    (8) evaporation

14. The sun's energy or radiation evaporates water from surface supplies (streams, rivers, lakes, oceans, etc.) into the atmosphere. This water vapor rises and collects to form clouds. Under certain conditions, this vapor condenses and falls back to the earth as precipitation. Some water vaporizes as it falls, while most of it infiltrates into the ground or runs off over the surface to streams, rivers, lakes and, in turn, back to the oceans. That portion which moves down into the ground may be stored for long periods of time or it may be discharged at springs or seeps. The cycle then repeats, with evaporation from surface water and transpiration from plants.

15. TRUE

FINAL CHECKOUT

	YES	NO
1. Explained the meaning of hydrologic cycle and defined related terms.	___	___
2. Listed four forms of precipitation	___	___
3. Sketched the hydrologic cycle and labeled all processes.	___	___
4. Identified the forces involved in the hydrologic cycle.	___	___
5. Described the movement of water through the hydrologic cycle.	___	___
6. Identified residence times for the various hydrologic cycle processes.	___	___
7. Explain the meaning of "water budget" in terms of the hydrologic cycle.	___	___
8. Established a water budget available for our use.	___	___
9. Identified portion of water budget available for our use.	___	___
10. Explained why certain areas are experiencing water shortages.	___	___
11. Listed means and methods to offset shortages.	___	___

GROUNDWATER AND GEOLOGY

Introduction:

Water is found throughout the earth as a liquid, solid, or vapor. The total volume of water is enormous occupying some 1,460,000,000 cubic kilometers. Yet only a small portion of this water is available for our use. Most water is found in the oceans as salt water or around the poles as glacial ice. That portion found below the earth's surface in the pores of soil and rock is known as groundwater. The amount of groundwater available and its chemical and bacteriological characteristics are determined to a large extent by the geology of the area. Approximately eighty percent of all public water supply systems in the United States utilize groundwater. Yet the largest number of people in this country are served by fresh water surface supplies (lakes or rivers). As the population increases though, and surface water becomes subject to abuse and reuse, groundwater may play a more important role in terms of satisfying our water needs in some areas of the country. Waterworks operators and water supply engineers must keep a close watch on groundwater trends to insure that groundwater is not mined (withdrawn at a rate faster than natural replenishment) because mining groundwater supplies could lead to serious economic and social problems.

Objectives:

1. LIST six major occurrences of water and RANK them according to volume.
2. IDENTIFY those occurrences suitable for our use.
3. EXPLAIN why majority of utilities in the United States use groundwater, while the majority of people use surface water.
4. LIST some advantages and disadvantages of groundwater in comparison to surface water.
5. DEFINE the following terms: zone of aeration, zone of saturation, water table, infiltration, groundwater, surface water, aquifer, field capacity, impervious layer, perched water table, artesian well, recharge area, discharge area, formation, porosity, permeability.
6. EXPLAIN the process by which water goes underground.
7. EXPLAIN how groundwater is located.

Objectives (continued):

8. IDENTIFY two groundwater sources.

9. STATE characteristics of a good aquifer and IDENTIFY three types of formations which would serve as good aquifers.

10. DRAW cross-sectional views of water table and artesian wells.

11. LIST five factors which determine the depth at which groundwater is found.

12. IDENTIFY and EXPLAIN factors affecting rate of infiltration.

13. STATE two factors that influence the horizontal rate of groundwater movement underground.

14. EXPLAIN how water table levels are affected by the seasons.

15. LIST factors which affect chemical and biological quality of groundwater.

16. EXPLAIN why waterworks operators should have a knowledge of the geologic history of this area.

17. LIST four users of groundwater.

18. DESCRIBE recent trends in water demand and use.

19. IDENTIFY areas in the United States with groundwater overdraft.

20. LIST two negative side effects of heavy groundwater use.

21. SUGGEST two remedies to help eliminate undesirable side effects of heavy groundwater use.

22. DISCUSS future use of groundwater throughout the United States.

Learning Activities:

1. LISTEN to presentation on groundwater and geology.
2. VIEW film: "Ground Water: Hidden Reservoir."
3. READ pages 4-13, AWWA Manual M21, and pages 4-6, AWWA Manual M18.
4. SKIM Chapter 3, AWWA Manual M21, paying attention to geophysical methods section.
5. EXAMINE geologic time scale, Geologic Map of Wisconsin, and Wisconsin Glacial Deposits Map.
6. COMPLETE Worksheet.
7. COMPLETE Student Self-check and CHECK answers.
8. PROCEED to Final Checkout.

WORKSHEET

1. Water occurs in many phases and many places. List six major occurrences and rank them in order of volume (1 being the greatest, 6 being the least).

Occurrence	Rank

2. Identify those occurrences which are suitable for our use.

3. Explain why the majority of public water supply facilities in the United States use groundwater, while the majority of people use surface water.

4. List three advantages of groundwater over surface water.

   (1) _____

   (2) _____

   (3) _____

5. List two disadvantages of groundwater.

(1) _____

(2) _____

6. Define the following terms:

zone of aeration _____

_____

zone of saturation _____

_____

water table _____

_____

infiltration _____

_____

groundwater _____

_____

surface water _____

_____

aquifer _____

_____

field capacity _____

_____

impervious layer _____

_____

perched water table _____

_____

artesian well _____

_____

recharge area _____

_____

discharge area _____

_____

formation _____

_____

porosity _____

_____

permeability _____

_____

7. Explain in your own words the process of how water moves underground.

_____

_____

_____

_____

8. Explain in your own words how groundwater is located.

_____

_____

_____

_____

9. Identify two groundwater sources.

(1) _____

(2) _____

10. State two purposes of an aquifer.

(1) _____

(2) _____

11. State three characteristics of a good aquifer.

(1) _____

(2) _____

(3) _____

12. Name three types of formations which could serve as good aquifers.

_____

_____

_____

13. Name two formations which would not serve as aquifers.

_____

_____

14. What formation does your well water come from?

15. Draw cross-sectional views of water table and artesian wells.

16. List five factors which determine the depth at which groundwater is found.

(1) _____

(2) _____

(3) _____

(4) _____

(5) _____

17. Identify two factors that affect the rate of infiltration and explain each.

(1) _____: _____

_____

(2) _____: _____

_____

18. Name two factors that influence the horizontal rate of groundwater movement.

_____

_____

19. Explain how groundwater levels are affected by the seasons by drawing a diagram showing how precipitation varies throughout the year and how the water table varies with precipitation.

20. Identify three factors which affect the chemical and/or biological quality of groundwater and explain each.

_____

_____

_____

_____

21. Why is groundwater from deep aquifers generally bacteriologically safe?

_____

_____

22. Is groundwater generally richer or poorer in minerals when compared to surface water?

_____

23. Why should a waterworks operator have a general understanding of the geologic history of his or her area?

_____

_____

_____

24. What is the geologic history of your area? What effects has this had on your groundwater in terms of location and quality?

25. List four users of groundwater.

(1) _____

(2) _____

(3) _____

(4) _____

26. Have there been any recent trends in water demand and water use? If so, what are they?

_____

_____

27. Identify areas of the United States with groundwater overdraft.

_____

_____

28. List two negative side effects heavy groundwater use may have.

_____

29. Describe one way to help eliminate each of the negative side effects listed in Question #28.

_____

_____

30. In your own words, discuss the use of groundwater in the next fifty years.

_____

_____

_____

_____

_____

_____

STUDENT SELF-CHECK

____ 1. Groundwater is generally colorless, free of contaminants, and bacteriologically safe. TRUE or FALSE?

____ 2. Heavy groundwater use may cause land subsidence. TRUE or FALSE?

____ 3. Recent trends show that demand for water is growing faster than the population. TRUE or FALSE?

____ 4. Water-table wells and artesian wells draw water from the same aquifer. TRUE or FALSE?

____ 5. Which of the following formations would not make a good aquifer?

a. sandstone
b. limestone
c. dolomite
d. clay
e. all of the above

____ 6. Which of the following determine the depth at which groundwater is found?

a. hydrologic cycle
b. topography of the area
c. permeability of rock
d. amount of water withdrawn from wells
e. all of the above

____ 7. Which of the following affect percolation?

a. intensity of rainfall
b. slope of the land
c. permeability of rock
d. degree of soil saturation
e. all of the above

____ 8. Which of the following affect groundwater quality?

a. depth water percolates
b. composition of rock
c. time held underground
d. all of the above

Directions for Questions #9 through #18: MATCH the terms with their definitions.

____ 9. aquifer	a. volume of pore spaces compared to total volume of formation
____ 10. water table	b. area where water enters ground easily
____ 11. porosity	c. movement of water after it enters the ground
____ 12. permeability	d. water-bearing formation
____ 13. recharge area	e. a situation where water rises above water table
____ 14. perched water table	f. ability of water to pass through the rock
____ 15. infiltration	g. boundary between zone of aeration and zone of saturation
____ 16. artesian well	h. water saturated zone lying within zone of aeration
____ 17. impervious layer	i. section which retards infiltration
____ 18. discharge area	j. spring

ANSWERS TO STUDENT SELF-CHECK

1.	TRUE	10.	g
2.	TRUE	11.	a
3.	TRUE	12.	f
4.	FALSE	13.	b
5.	d	14.	h
6.	e	15.	c
7.	e	16.	e
8.	d	17.	i
9.	d	18.	j

FINAL CHECKOUT

		YES	NO
1.	Listed six major occurrences of water and ranked them according to volume.	___	___
2.	Identified occurrences suitable for our use.	___	___
3.	Explained why the majority of utilities in the United States use groundwater, while the majority of people use surface water.	___	___
4.	Listed advantages and disadvantages of groundwater in comparison to surface water.	___	___
5.	Defined terms related to groundwater and geology.	___	___
6.	Explained how water goes underground.	___	___
7.	Explained how groundwater is located.	___	___
8.	Identified two groundwater sources.	___	___
9.	Stated characteristics of a good aquifer and identified three types of formations which would serve as good aquifers.	___	___
10.	Drew cross-sectional views of water table and artesian wells.	___	___

	YES	NO
11. Listed five factors which determine the depth at which groundwater is found.	___	___
12. Identified and explained factors affecting the rate of infiltration.	___	___
13. Stated two factors that influence the horizontal rate of groundwater movement.	___	___
14. Explained how water table levels are effected by the seasons.	___	___
15. Listed factors which affect chemical and biological quality of groundwater.	___	___
16. Explained why waterworks operators should have a knowledge of geologic history in their area.	___	___
17. Listed four users of groundwater.	___	___
18. Described recent trends in water demand and use.	___	___
19. Identified areas in United States with groundwater overdraft.	___	___
20. Listed two negative side effects heavy groundwater use may have.	___	___
21. Suggested two remedies to help eliminate side effects of heavy groundwater use.	___	___
22. Discussed the future of groundwater use.	___	___

WELL CONSTRUCTION

Introduction:

Of the fresh water available for our use, less than five percent is found in streams and lakes. The other 95 percent--an estimated 9,850,000 cubic kilometers--is underground. In order to tap this underground resource, wells are drilled.

Ancient Persians constructed tunnels and shafts to tap groundwater, while the early Egyptians and Chinese were familiar enough with drilling methods to sink boreholes to obtain groundwater. Today, however, construction techniques have advanced to such an extent that approximately 80 percent of all U. S. public water systems are able to utilize groundwater.

In this module, you will learn about the various types of wells, well construction methods and materials, and terms and processes related to well construction and use.

Objectives:

1. STATE characteristics of an ideal municipal well location.
2. NAME three sanitary hazards that should not be near a well.
3. IDENTIFY two basic types of materials in which wells are drilled.
4. LIST five types of wells.
5. DESCRIBE the uses and limitations of driven, drilled, and radial wells.
6. NAME five methods of constructing a drilled well.
7. IDENTIFY the basic steps in drilling a well in consolidated and unconsolidated formations.
8. EXPLAIN the principles of drilling a well with the cable tool, rotary, and reverse rotary methods.
9. EXPLAIN the need for collecting formation samples as drilling progresses.
10. IDENTIFY the type of construction used in your community's well.

Objectives (continued):

11. DESCRIBE the purpose of well casing.
12. EXPLAIN how well casing is installed in both the cable tool and rotary methods.
13. GIVE four reasons why wells are grouted.
14. DESCRIBE the grouting process.
15. EXPLAIN the purpose of screens in well construction.
16. IDENTIFY three types of screens and DESCRIBE each.
17. LIST factors which affect the size of the openings in a well screen.
18. EXPLAIN when gravel wall well construction is used.
19. SKETCH a drilled well in a consolidated formation and an unconsolidated formation, a gravel wall well, and a radial well.
20. STATE the purpose behind well development.
21. LIST and DESCRIBE four methods of well development.
22. LIST three types of bacteria found in wells and DESCRIBE their characteristic properties.
23. EXPLAIN how water well disinfection is accomplished.
24. IDENTIFY methods available to determine water levels in wells.
25. Given a cross-sectional sketch of a typical well, IDENTIFY the air line, pressure gage, static water level, pumping water level, drawdown, and cone of depression.
26. Using altitude gage readings, DETERMINE the static and pumping water levels in a well.
27. DEFINE specific capacity.
28. Given static water level, pumping water level and pumping rate, CALCULATE the specific capacity of a well.
29. STATE how often water levels and specific capacity should be measured.

Objectives (continued):

30. IDENTIFY two forms of encrustation found in well screens.
31. EXPLAIN two methods of well rehabilitation.
32. GIVE two reasons for a drop in the pumping water level.
33. GIVE two reasons for a drop in the specific capacity of a well.
34. EXPLAIN remedial measures for drop in static water level, drop in pumping water level, and drop in specific capacity.
35. EXPLAIN the effect well pumping can have on adjacent wells.
36. DESCRIBE the temporary abandonment procedure (NR 111) for wells.
37. DESCRIBE the abandonment procedures specified in NR 111 for wells in various formations.

Learning Activities:

1. READ AWWA Manual M21, Chapters 4 and 6.
2. SKIM AWWA Manual M21, Chapter 5.
3. LOCATE and READ Chapter NR 111, Wisconsin Administrative Code, sections .26, .31, .32, .33, .34.
4. LISTEN to presentation on well construction.
5. VIEW Layne Northwest film, "Deep Water," and DNR well construction slide presentation.
6. COMPLETE Worksheet.
7. COMPLETE Student Self-check and CHECK answers.
8. PROCEED to Final Checkout.

WORKSHEET

1. What factors determine where a municipal water well is located?

2. Name three sanitary hazards that should not be located near a municipal water well.

   (1) _____

   (2) _____

   (3) _____

3. What are the two basic types of materials wells are drilled in? Give examples of each.

   (1) _____; _____

   (2) _____; _____

4. List five types of wells.

   (1) _____

   (2) _____

   (3) _____

   (4) _____

   (5) _____

5. Describe the uses and limitations of each of the following types of wells:

driven _____

_____

_____

drilled _____

_____

_____

radial _____

_____

_____

6. List five methods of constructing a drilled well.

(1) _____

(2) _____

(3) _____

(4) _____

(5) _____

7. What are the basic steps in drilling a drilled well in consolidated and unconsolidated materials?

Consolidated	Unconsolidated
a. _____	a. _____
b. _____	b. _____
c. _____	c. _____
d. _____	d. _____
	e. _____

8. Explain the principals of drilling a drilled well with the cable tool, rotary, and reverse rotary methods.

cable tool _____

_____

_____

rotary _____

_____

_____

reverse rotary _____

_____

_____

9. Why is it necessary for well drillers to collect formation samples as drilling progresses?

_____

_____

10. What type of construction was used in your community's municipal well?

_____

11. What is the purpose of a well casing?

_____

_____

12. How is casing installed in the cable tool and rotary methods?

cable tool _____

_____

_____

rotary _____

_____

_____

13. Wells are grouted for a variety of reasons. List four.

(1) _____

(2) _____

(3) _____

(4) _____

14. In your own words describe three methods of grouting.

15. What is the purpose of a well screen?

_____

_____

16. In what types of formations are well screens usually installed?

_____

17. Identify three types of well screens and describe each.

(1) _____

_____

(2) _____

_____

(3) _____

_____

18. What factors affect the size of the openings (slot size) in a well screen?

_____

_____

19. When is gravel wall well construction used?

_____

20. In the space below sketch the following:

a. drilled well in a consolidated formation
b. drilled well in a unconsolidated formation
c. gravel wall well
d. a radial well

21. After a well is in place, it must be developed. What is the purpose of development?

_____

_____

22. List four methods of development and briefly describe each.

(1) _____

_____

_____

(2) _____

_____

_____

(3) _____

_____

_____

(4) _____

_____

_____

23. List three types of bacteria found in wells and their characteristic properties.

	Bacteria	Properties
(1)	_____	_____
(2)	_____	_____
(3)	_____	_____

24. How is water well disinfection accomplished?

_____

_____

_____

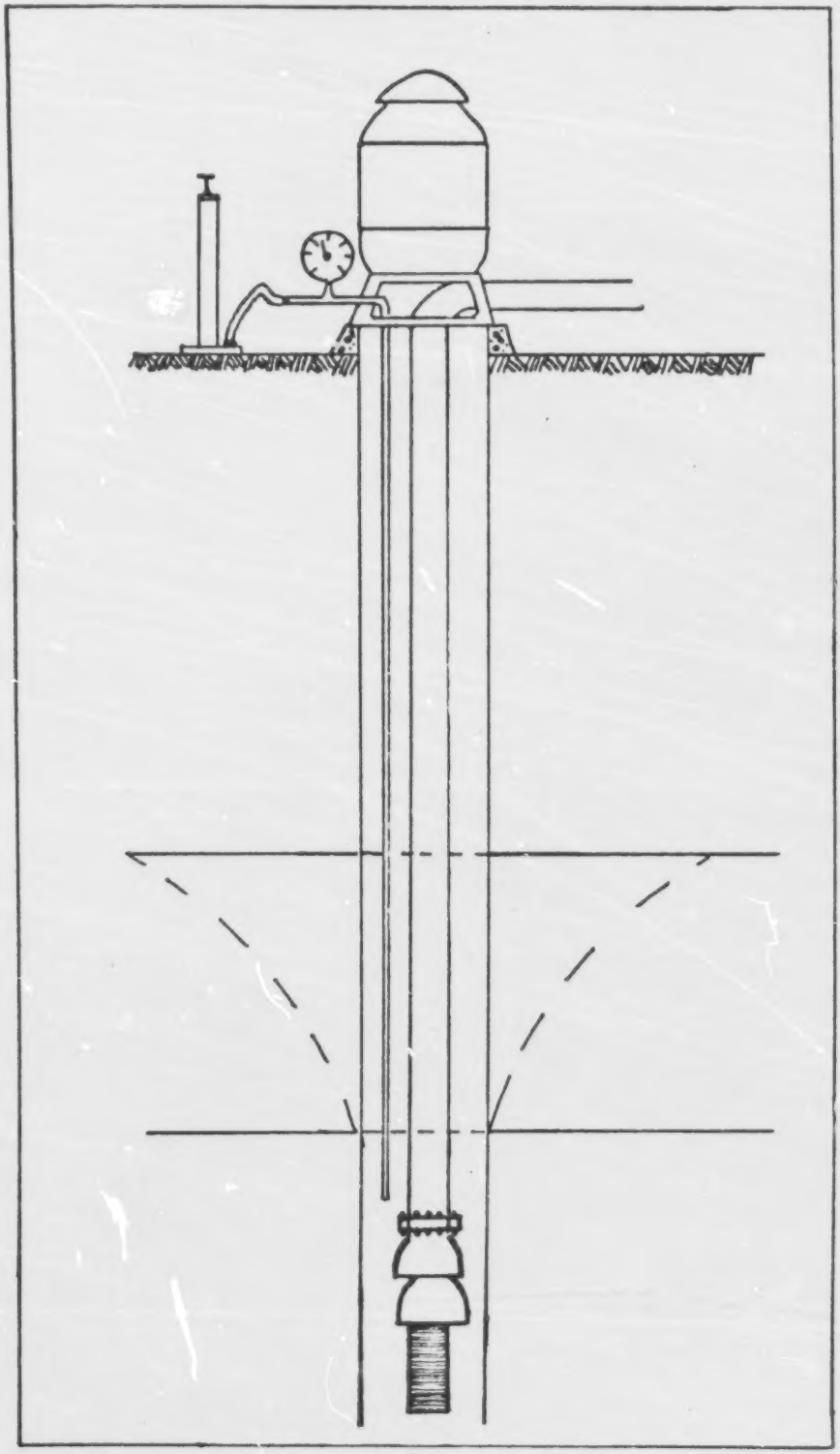
25. List three methods to determine water levels in a well.

(1) _____

(2) _____

(3) _____

26. On the following diagram, showing the cross-section of a typical well, identify the air line, pressure gage, static water level, pumping water level, drawdown, and cone of depression.



S.5

27. Define specific capacity.

28. Given the following: airline length of 375'; when pump is at rest, gage reads 150'; when pump is running for some time, gage reads 60'; and pumping rate of 200 gpm.

Find: static water level _____

pumping water level _____

drawdown _____

specific capacity _____

29. How often should water levels and the specific capacity of a well be tested?

_____

30. List two forms of encrustration on a well screen.

(1) _____

(2) _____

31. Explain two methods used in treating encrusted wells.

(1) _____

_____

(2) _____

_____

32. List two possible reasons for a drop in the pumping water level.

_____

_____

33. Give two reasons for a drop in the specific capacity of a well.

_____

_____

34. Describe some possible remedial measures for the following:

drop in static water level -

drop in pumping water level -

drop in specific capacity -

35. What effect can well pumping have on adjacent wells?

_____

_____

36. In your own words, describe the temporary abandonment procedure (NR 111) for wells.

37. Again in your own words, describe the abandonment procedure specified in NR 111 for wells in your area.

_____

_____

_____

_____

_____

STUDENT SELF-CHECK

1. Which of the following sanitary hazards should not be near a municipal well?

   a. feed lot
   b. sanitary landfill
   c. septic or sewer tanks
   d. gasoline or oil tanks
   e. all of the above

Use the following information for Questions #2 through #5:

air line length of 500'
gage reads 210' when pump is at rest
gage reads 75' when pump is running
pumping rate OF 175 gpm

2. The static water level is:

   a. 135'
   b. 210'
   c. 290'
   d. 425'

3. The pumping water level is:

   a. 75'
   b. 210'
   c. 290'
   d. 425'

4. The drawdown is:

   a. 75'
   b. 135'
   c. 175'
   d. 290'

5. The specific capacity is:

   a. 1.3 gpm/ft
   b. 1.8 gpm/ft
   c. 4.6 gpm/ft
   d. 13.0 gpm/ft

6. A drop in specific capacity may be due to:

   a. plugged aquifer
   b. nearby well
   c. wet season
   d. worn out pump

7. What type of well construction is used to obtain water from a deep aquifer?

   a. dug method
   b. driven method
   c. drilled method
   d. radial method

8. All of the following are reasons for grouting except:

   a. protect against contamination
   b. stabalize the formation from caving
   c. protect against exterior corrosion of casing
   d. increase the yield of the well

9. Initial starting of a well pump shows 30.5 psi on the pressure gage. After pumping one hour, the pressure gage reads 25.5 psi. How many feet of drawdown occurred in that hour?

   a. 1.15
   b. 10.55
   c. 11.55
   d. 115.5

10. Well screens allow water to flow freely into a well while providing support in unconsolidated formations and prevent sand from entering the well. TRUE or FALSE?

11. Gravel wall wells are usually constructed in granite formations. TRUE or FALSE?

12. The primary purpose of well development is to check for any leaks in the grout seal. TRUE or FALSE?

Directions for Questions #13 through #15: MATCH the type of bacteria with its description.

____ 13.	iron bacteria	a.	rotten egg odor
____ 14.	hydrogen-sulfide bacteria	b.	indicators of contamination
____ 15.	coliform bacteria	c.	fuel oil or kerosene odor

ANSWERS TO STUDENT SELF-CHECK

1. e
2. c
3. d
4. b
5. a
6. a
7. c
8. d
9. c
10. TRUE
11. FALSE
12. FALSE
13. c
14. a
15. b

FINAL CHECKOUT

		YES	NO
1.	Stated ideal characteristics for a municipal well location.	___	___
2.	Named three sanitary hazards that should not be near a well.	___	___
3.	Identified two types of materials wells are drilled in.	___	___
4.	Listed five types of wells.	___	___
5.	Described the uses and limitations of driven, drilled and radial wells.	___	___
6.	Named five methods of constructing a drilled well.	___	___
7.	Identified the basic steps for drilling in consolidated and unconsolidated formations.	___	___
8.	Explained principals of drilling a well with the cable tool, rotary, and reverse rotary method.	___	___
9.	Explained the need for collecting formation samples as drilling progresses.	___	___
10.	Identified type of construction in own community's well.	___	___
11.	Described purpose of well casing.	___	___

		YES	NO
12.	Explain how well casing is installed in drilled methods.	___	___
13.	Gave four reasons why wells are grouted.	___	___
14.	Described grouting process.	___	___
15.	Explained purpose of well screen in well construction.	___	___
16.	Identified three types of screens and described each.	___	___
17.	Listed factors which affected the size of the screen openings in a well screen.	___	___
18.	Explained when gravel wall well construction is used.	___	___
19.	Sketched a drilled well in a consolidated and unconsolidated formation, a gravel wall well, and a radial well.	___	___
20.	Stated the purpose behind well development.	___	___
21.	Listed and described four methods of well development.	___	___
22.	Listed three types of bacteria found in wells and described their characteristic properties.	___	___
23.	Explained how water well disinfection is accomplished.	___	___
24.	Identified methods to determine water levels in wells.	___	___
25.	Identified features on sketch of a typical well.	___	___
26.	Determined static and pumping water levels using altitude gage readings.	___	___
27.	Defined specific capacity.	___	___
28.	Calculated specific capacity of a well using given data.	___	___
29.	Stated how often water levels and specific capacity should be measured.	___	___
30.	Identified two forms of encrustations on well screens.	___	___
31.	Explained two methods of well rehabilitation.	___	___
32.	Gave two reasons for a drop in the pumping water level of a well.	___	___

	YES	NO
33. Gave two reasons for a drop in the specific capacity of a well.	___	___
34. Explained remedial measures for: drop in static water level, drop in pumping water level, and drop in specific capacity of a well.	___	___
35. Explained effect of well pumping on adjacent wells.	___	___
36. Described temporary abandonment procedures for wells.	___	___
37. Described abandonment procedures for wells.	___	___

PUMPS

Introduction:

A pump is an apparatus which transfers energy to raise, propel or compress fluids and/or gases. There are numerous pump types and designs, each having specific applications.

Early applications of pumps to move water were found in China, India, Greece, and Egypt some 3,500 years ago. Today pumps are still used to move water. Centrifugal and vertical turbine pumps are used in many public water supply facilities to lift water from one location to another or to increase water pressure. Centrifugal pumps are quite popular because of their low comparative cost, their compactness, and their operational simplicity and variability. Another pump now found at some water supply facilities is a submersible pump, one with a submerged motor close to the pumping unit. This pump offers the advantages of silent operation and being able to pump water in crooked wells unsuited for other pumps.

This module discusses centrifugal, vertical turbine, and submersible pumps in regard to construction, operation, and maintenance.

Objectives:

1. LIST three requirements for pumps used in public water supply facilities.

2. LIST five types of pumps.

3. DIFFERENTIATE between high lift and low lift pumps.

4. IDENTIFY and DESCRIBE the functions of the following parts of a centrifugal pump: impeller, shaft, sleeves, bearings, lantern ring, mechanical seal, pump casing, packing gland, volute.

5. DESCRIBE how a centrifugal pump operates.

6. LIST some advantages and disadvantages of a centrifugal pump.

7. IDENTIFY and DESCRIBE the functions of the following parts of a vertical turbine pump: motor, pump head, impeller, bowl assembly, packing, shaft, thrust bearing, strainer, spider.

Objectives (continued):

8. DESCRIBE how a vertical turbine pump works.
9. IDENTIFY situations in which a vertical turbine pump is more advantageous than a centrifugal pump.
10. EXPLAIN the term submersible pump.
11. DESCRIBE how a submersible pump works.
12. LIST the major parts of a submersible pump.
13. LIST some advantages and disadvantages of a submersible pump.
14. STATE purpose of a booster pump.
15. DESCRIBE typical booster pump set-up.
16. LIST three types of prime movers available for pumps.
17. IDENTIFY six factors which must be considered in determining pump size and type.
18. DEFINE the following terms: discharge head, suction head, friction head, flow rate, pump efficiency, pump capacity, brake horsepower, water horsepower, total head, cavitation.
19. IDENTIFY various features in a typical pump house.
20. OUTLINE a pump start up procedure for centrifugal and vertical turbine pumps.
21. DESCRIBE desirable pump operating conditions.
22. DESCRIBE good operational and maintenance procedures in relation to: priming, packing, bearings, alignment.
23. LIST possible causes and remedies for the following pump symptoms.

    a. short bearing life
    b. cavitation
    c. short packing life
    d. vibrating pump
    e. pump loses prime
    f. reduced rate of discharge
    g. pump will not start

Objectives (continued):

24. LIST two possible reasons for a pump breaking suction.

25. EXPLAIN cause of sand pumping and its effect on pump and valves.

26. DISCUSS what an operator should do in relation to a system's pumps if there is a power failure in the community.

27. DISCUSS the use of standby power and name various types.

28. OUTLINE a preventive maintenance program for pumps.

Learning Activities:

1. READ Chapter 7, M21; Chapter 13, M18: Chapter 3, M8.

2. LISTEN to presentation.

3. EXAMINE and READ handout material provided by Instructor.

4. EXAMINE sample pumps and pump parts.

5. VIEW "Pump Maintenance," video tape.

6. COMPLETE Worksheet.

7. COMPLETE Student Self-check and CHECK answers.

8. PROCEED to Final Checkout.

WORKSHEET

1. What are three basic requirements for pumps that are used in public water supply facilities?

   (1) _____

   (2) _____

   (3) _____

2. List five types of pumps.

   (1) _____

   (2) _____

   (3) _____

   (4) _____

   (5) _____

3. Differentiate between low lift and high lift pumps.

4. Identify the following parts in the drawing below:

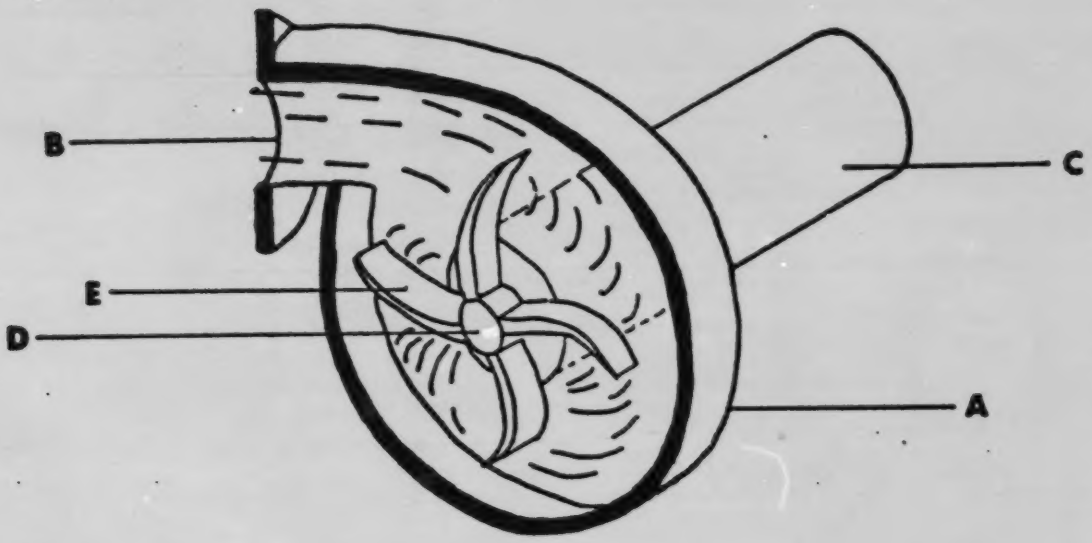
_____ impeller

_____ volute

_____ discharge

_____ suction

_____ impeller eye



Volute –Type Centrifugal Pump

5. Identify the following parts in the centrifugal pump drawing below.

_____ impeller

_____ shaft

_____ sleeve

_____ packing

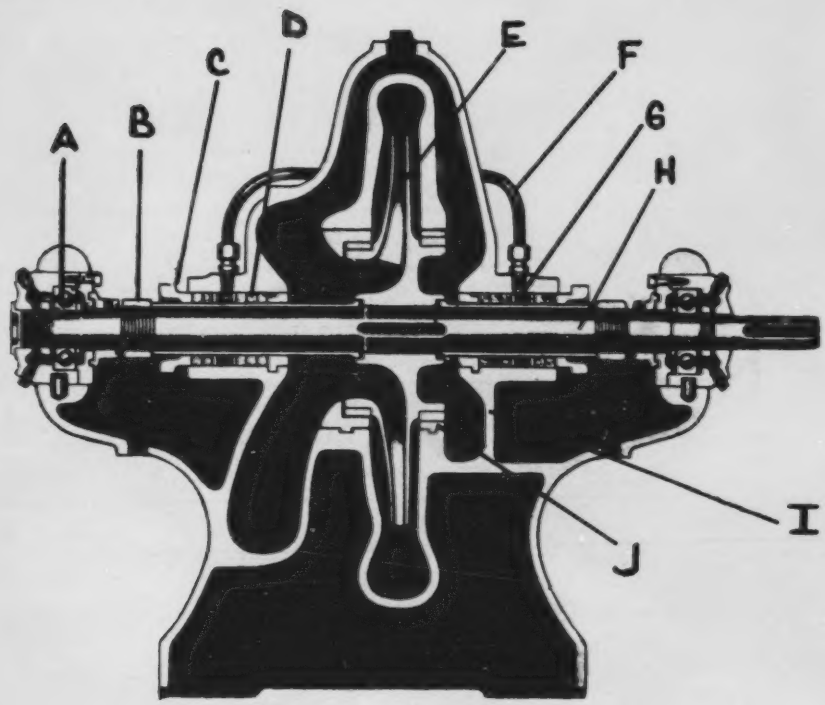
_____ packing gland

_____ lantern ring

_____ water line to lantern wing

_____ pump casing

_____ bearing



6. What is the function of each of the following?

impeller _____

_____

shaft _____

_____

sleeve _____

_____

packing _____

_____

packing gland _____

_____

lantern ring _____

_____

water line to lantern ring _____

_____

pump casing _____

_____

bearing _____

_____

volute _____

_____

7. In your own words, describe how a centrifugal pump operates.

_____

_____

_____

_____

8. List two advantages of a centrifugal pump.

(1) _____

(2) _____

9. List two disadvantages of a centrifugal pump.

(1) _____

(2) _____

10. Identify the following in the vertical turbine pump drawing below.

_____ water lubricated shaft bearing

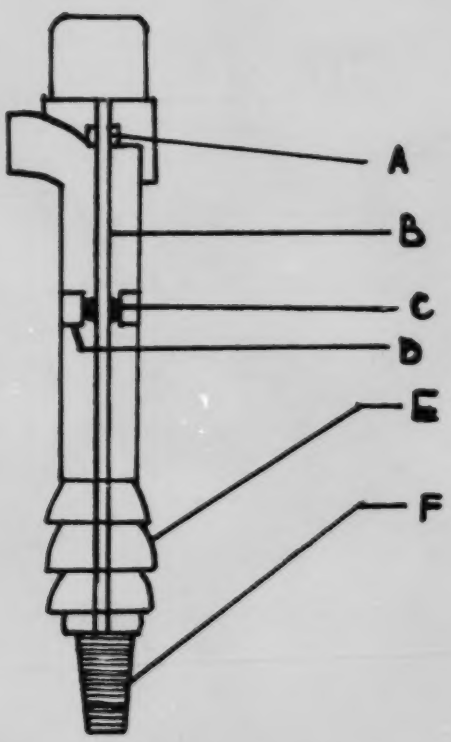
_____ bowl assembly

_____ packing

_____ shaft

_____ strainer

_____ spider



11. What is the function of each of the following?

water lubricated shaft bearing _____

_____

bowl assembly _____

_____

packing _____

_____

shaft _____

_____

strainer _____

_____

spider _____

_____

12. In your own words, describe how a vertical turbine pump works.

_____

_____

_____

_____

13. Where would a vertical turbine pump work better than a centrifugal pump?

_____

14. If one stage on a vertical turbine pump delivers 250 gpm at 10 ft. of head, how many stages are needed to deliver 250 gpm at 75 ft. of head?

15. What is a submersible pump?

16. What are the major parts that compose a submersible pump?

17. What are two advantages of a submersible pump?

    (1) _____

    (2) _____

18. What are two disadvantages of a submersible pump?

    (1) _____

    (2) _____

19. What is the purpose of a booster pump?

    _____

    _____

20. Where are booster pumps found?

    _____

21. In your own words, describe a typical booster pump set-up.

22. List three types of prime movers for pumps.

    (1) _____

    (2) _____

    (3) _____

23. What six factors must be considered in determining pump size and type?

(1) _____

(2) _____

(3) _____

(4) _____

(5) _____

(6) _____

24. Define the following terms.

discharge head _____

_____

suction head _____

_____

friction head _____

_____

flow rate _____

_____

pump efficiency _____

_____

pump capacity _____

_____

brake horsepower _____

_____

water horsepower _____

_____

total head _____

_____

cavitation _____

_____

25. Explain how to read a pump curve.

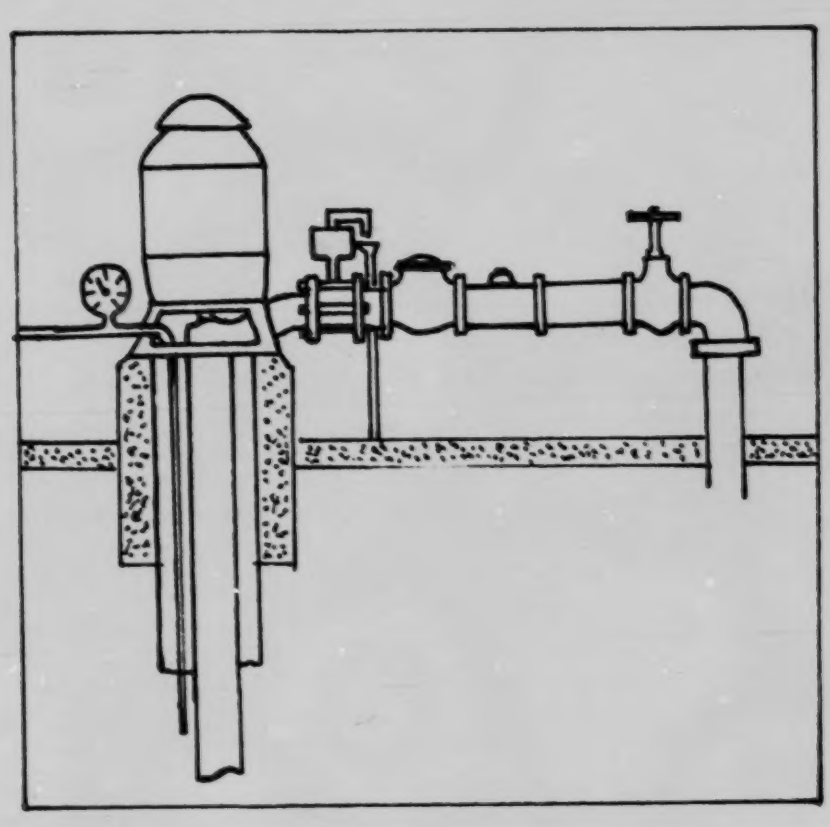
_____

_____

_____

_____

26. In the following diagram, identify the water meter, check valve, gate valve, flexible coupling, air release valve, pump head and motor.



27. Outline step by step program to start up a centrifugal and vertical turbine pump

Centrifugal	Turbine

28. Why must a pump be primed?

_____

_____

29. Explain two ways to prime a pump.

(1) _____

_____

_____

(2) _____

_____

_____

30. Variations from normal operating conditions indicate trouble. Describe normal operating conditions for your pumps.

_____

_____

_____

31. How can you tell when packing is tightened properly?

_____

32. What are the sizes of worn packing?

33. What is the composition of packing? Why are those materials used?

34. Explain how to repack a pump.

35. An operator should never over-grease or over-oil a pump. TRUE or FALSE? Explain your answer.

36. What effect will too much grease have on a bearing?

37. Why should alignment be checked periodically?

38. Is it better for a pump to run continuously or start and stop? Why?

_____

_____

_____

39. List a possible cause and a remedy for each of the following problems.

PROBLEM	POSSIBLE CAUSE	REMEDY
short bearing life		
cavitation		
short packing life		
vibrating pump		
pump loses prime		
reduced rate of discharge		
pump will not start		

40. What are two reasons a pump might break suction?

(1) _____

(2) _____

41. Often, operators complain of sand pumping. What is sand pumping, the cause of it, and what does it do to a pump and valves?

_____

_____

_____

42. If your waterworks experienced a power failure, what would you do to continue providing water for your customers?

_____

_____

_____

43. What should an operator do in case of a well pump failure?

_____

_____

44. List three types of standby power.

(1) _____

(2) _____

(3) _____

45. How is the switch-over from regular to standby power accomplished at your facility?

_____

_____

_____

46. How often should you test your standby power?

_____

47. How often should a well be pumped by standby power?

_____

48. Outline a preventive maintenance program for the pumps at your waterworks.

STUDENT SELF-CHECK

____ 1. After proper adjustment of a well pump, you can tell it needs new packing if:

a. excess water is leaking out
b. shaft will not turn
c. bearings start to make too much noise
d. stuffing box is warm

____ 2. Cavitation is a problem in pumps because it can cause:

a. excessive wear on impeller
b. reduced pumping efficiency
c. vibration in the pump
d. too much noise
e. all of the above

____ 3. Two causes of cavitation are:

a. high suction head or high discharge head
b. water that is too hot or too cold
c. air getting pulled into well or water tower
d. high suction lift or pumping too fast

____ 4. Standby power should be run:

a. once a day
b. twice a week
c. twice a month
d. once a month

____ 5. Pump manuals are:

a. kept under the pump
b. kept in a file
c. sources of useful information
d. both a and b
e. both b and c

____ 6. Which of the following is <u>not</u> a cause for a vibrating pump?

a. misalignment
b. speed too low
c. worn bearings
d. tight packing

____ 7. Water is often run down a pump column prior to starting a vertical turbine pump in order to:

a. prime the pump
b. lubricate the shaft bearing
c. coat the mechanical seal
d. prevent contamination

____ 8. If a one stage vertical turbine pump delivers 300 gpm at 25 ft. of head, how many stages are necessary to deliver 300 gpm at 200 ft. of head?

a. 1
b. 4
c. 8
d. 12

____ 9. Which of the following is <u>not</u> a reason for a pump losing its prime:

a. suction line may be leaking
b. glands too loose
c. suction pressure may be too low
d. pumped liquid may contain air or gas

____ 10. What type of pump is most often found in a crooked well:

a. centrifugal pump
b. vertical turbine pump
c. submersible pump
d. piston pump

____ 11. A centrifugal pump should be primed before starting to insure maximum capacity. TRUE or FALSE?

____ 12. An operator should add a "shot" of grease each week to keep the pumps lubricated. TRUE or FALSE?

____ 13. Preventive maintenance is daily or periodic checks on equipment to insure proper performance. TRUE or FALSE?

____ 14. Packing should generally be cut at a bias and then staggered around the sleeve. TRUE or FALSE?

ANSWERS TO STUDENT SELF-CHECK

1. a	8. c
2. e	9. b
3. d	10. c
4. c	11. TRUE
5. e	12. FALSE
6. b	13. TRUE
7. b	14. TRUE

FINAL CHECKOUT

	YES	NO
1. Listed three requirements for pumps used in public water supply facilities.	___	___
2. Listed five types of pumps.	___	___
3. Differentiated between high lift and low lift pumps.	___	___
4. Identified and described functions of given parts of a centrifugal pump.	___	___
5. Described how a centrifugal pump operates.	___	___
6. Listed advantages and disadvantages of a centrifugal pump.	___	___
7. Identified and described the functions of given parts of a vertical turbine pump.	___	___
8. Described how a vertical turbine pump works.	___	___
9. Identified situations in which a vertical turbine pump is more advantageous than a centrifugal pump.	___	___
10. Explained the term submersible pump.	___	___
11. Described how a submersible pump works.	___	___
12. Listed major parts of a submersible pump.	___	___

		YES	NO
13.	Listed advantages and disadvantages of a submersible pump.	___	___
14.	Stated purpose of a booster pump.	___	___
15.	Described typical booster pump set-up.	___	___
16.	Listed three types of prime movers available for pumps.	___	___
17.	Identified six factors which must be considered in determining pump size and type.	___	___
18.	Defined given terms related to pumps.	___	___
19.	Identified features in a typical pump house.	___	___
20.	Outlined pump start up procedures for centrifugal and vertical turbine pumps.	___	___
21.	Described desirable pump operating conditions.	___	___
22.	Described good operational and maintenance procedures in relation to priming, packing, bearings, and alignment.	___	___
23.	Listed possible causes and remedies for given pump symptoms.	___	___
24.	Listed two possible reasons for a pump breaking suction.	___	___
25.	Explained cause of sand pumping and its effect on pump and valves.	___	___
26.	Discussed what an operator should do in relation to the system's pumps if there is a power failure in the community.	___	___
27.	Discussed the use of standby power and named various types.	___	___
28.	Outlined a preventive maintenance program for pumps.	___	___

WATER CHEMISTRY

Introduction:

Because it is the most abundant substance on earth, we often take water for granted. We travel nation-wide expecting cool, clear, safe drinking water without ever giving it a second thought. Yet water is one of the more chemically complex substances and its combined properties make it one of the more unique.

Discovered in 1871 by Henry Cavendish, water consists of the elements hydrogen and oxygen. In the uncombined state, hydrogen and oxygen are both gases. When these gases combine in the ratio of two atoms of hydrogen to one atom of oxygen, water is formed, chemically represented at H_2O.

Water exhibits many properties which are unique to itself. In large bodies, water is a transparent, colorless liquid with a blue tinge. Water is approximately 830 times heavier than dry air and exists in three physical states: liquid, solid, and gas. It freezes at 0°C., boils at 100°C, and attains its maximum density at 3.99°C. When changing from liquid to solid, water expands approximately nine percent; as a solid, it occupies 1.11 times more space than as a liquid.

This module covers basic water chemistry information a waterworks operator needs to know to better understand water plant practices.

Objectives:

1. LIST four units of concentration and EXPLAIN what each means.
2. RELATE the various units of concentration to each other.
3. DEFINE the following terms: solvent, solute, solution, saturation point, precipitates, suspended.
4. DISCUSS the periodic table, identifying chemical symbols, names, rows and columns.
5. DESCRIBE the characteristics and properties of various elements as they relate to a waterworks operator.

Objectives (continued):

6. IDENTIFY various chemical compounds by names and by symbols.
7. DESCRIBE the characteristics and properties of given chemical compounds as they relate to a waterworks operator.
8. EXPLAIN the principal of how corrosion works.
9. IDENTIFY methods to control corrosion.
10. DEFINE pH and EXPLAIN its importance to waterworks plant operators.
11. LIST pH ranges for given substances.
12. DEFINE and DESCRIBE alkalinity.
13. DISCUSS the Baylis curve, its components, its use and its purpose.
14. INTERPRET the Baylis curve using given information.
15. DEFINE and DESCRIBE water hardness, including carbonate and non-carbonate hardness.
16. DISCUSS the problems hard water can create for the utility and the customers.
17. IDENTIFY hardness concentrations for soft and hard water.
18. LIST two methods of water softening and EXPLAIN how each works.
19. DISCUSS the problem of acid rainfall.

Learning Activities:

1. LISTEN to presentation on water chemistry.
2. READ Chapter 7, M18 and Chapter 9 and 10, M21.
3. EXAMINE Periodic Table.
4. EXAMINE State of Wisconsin/Department of Natural Resources 1970 Public Water Supply Data Book.

Learning Activities
(continued):

5. COMPLETE Worksheet.

6. COMPLETE Student Self-check and CHECK answers.

7. PROCEED to Final Checkout.

WORKSHEET

1. List four units of concentration commonly used in the waterworks field.

   (1) _____

   (2) _____

   (3) _____

   (4) _____

2. Identify the respective abbreviation for each unit listed in Question #1.

   (1) _____

   (2) _____

   (3) _____

   (4) _____

3. Explain the meaning of each unit listed in Question #1.

   (1) _____

   _____

   _____

   (2) _____

   _____

   _____

   (3) _____

   _____

   _____

   (4) _____

   _____

   _____

4. How do the various units relate to each other?

5. Express 250 mg/l as ppm.

6. Express 50 grains as ppm.

7. Express 250 ug/l as ppm.

8. Define the following terms:

solvent

solute

solution

saturation point

suspended

9. List the names for each of the following chemical symbols:

H _____

C _____

N _____

O _____

F _____

Na _____

Mg _____

Cl _____

Ca _____

Mn _____

Fe _____

Au _____

Hg _____

10. What role does each of the following elements play in water utility operations?

F _____

_____

_____

Mg _____

_____

_____

Ca _____

_____

_____

Fe _____

_____

_____

Mn _____

_____

_____

Cl _____

_____

_____

Au _____

_____

_____

11. At what concentrations do Fe and Mn cause problems?

Fe _____

Mn _____

12. Identify the names for each of the following compounds.

NO_3 _____

NO_2 _____

H_2S _____

$CaCO_3$ _____

NaOH _____

Na_2CO_3 _____

CaO _____

13. What role does each of the following play in water utility operations?

NO_3 _____

_____

_____

120

H_2S _____

_____

_____

$CaCO_3$ _____

_____

_____

14. In your own words, explain how corrosion works.

_____

_____

_____

_____

_____

_____

_____

_____

15. What methods are there available to control corrosion?

_____

_____

_____

_____

_____

16. What is pH? What does it tell you about the water?

_____

_____

_____

_____

17. A pH of 7 is _____, while below 7 is _____, and above 7 is _____. (basic, acidic, neutral)

18. In natural waters, pH ranges between _____

19. Give an approximate pH range for the following:

    a. strong acid (concentrated) _____

    b. strong base (concentrated) _____

20. What is the importance of pH to a waterworks operator?

_____

_____

_____

_____

21. What is alkalinity? What role does it play in water?

_____

_____

_____

_____

_____

22. What does the Baylis curve tell you?

_____

_____

_____

_____

23. Using information from the State of Wisconsin/DNR 1970 Public Water Supply Data book and the Baylis curve, determine your community's water quality.

24. Define water hardness.

_____

_____

25. What problems does hard water pose to the customer? To the utility?

_____

_____

_____

26. What two elements most often contribute to hardness?

_____

27. Hardness is usually divided into two categories, _____ (or temporary hardness which can be removed by boiling) and _____ (or permanent hardness which cannot be removed by heating).

28. Hardness is usually defined in what units.

_____

29. What is the general dividing line for hard and soft water?

_____

30. List two methods used to soften water.

(1) _____

(2) _____

31. In your own words, explain each method listed in Question #30.

(1) _____

_____

_____

_____

_____

_____

_____

(2) _____

_____

_____

_____

_____

_____

_____

32. How does acid rainfall form and what problems does it pose?

_____

_____

_____

_____

_____

_____

_____

_____

33. Will acid rainfall have any effect on you? If so, what?

STUDENT SELF-CHECK

1. Boiling water with a high nitrate concentration eliminates the problem. TRUE or FALSE?

2. Mg/l and ppm are equal for all practical purposes in the waterworks field. TRUE or FALSE?

3. H_2S is desirable in drinking water to prevent corrosion. TRUE or FALSE?

4. Various types of metallic pipes connected together can form galvanic connections which lead to corrosion. TRUE or FALSE?

5. Acid rain has been linked to the death of fish in certain lakes in northeast United States. TRUE or FALSE?

6. One of the more important characteristics of water is that it will dissolve a wide variety of substances. A liquid that dissolves a substance is a:

   a. solute
   b. solvent
   c. solution
   d. precipitant

7. What two elements are primarily responsible for water hardness?

   a. Ca, Mn
   b. Fe, Mg
   c. Ca, Mg
   d. F, Cl

8. If water was slightly alkaline, the pH would most likely be:

   a. 2
   b. 4
   c. 9
   d. 12

9. All of the following are methods of softening water except:

   a. chemical precipitation with lime or soda ash
   b. ion exchange
   c. distillation
   d. chlorination

Directions for Questions #11 through #21: MATCH the following terms and symbols with the correct definitions (Note: there are extra definitions).

____ 10. Mn	a. 1 ppm
____ 11. F	b. fluoride
____ 12. NO_3	c. 50 ppm
____ 13. 50 mg/l	d. critical iron concentration
____ 14. pH 7	e. Blue Babies
____ 15. .3 ppm	f. magnesium
____ 16. .05 ppm	g. neutral
____ 17. Fe	h. critical manganese concentration
____ 18. Baylis Curve	i. manganese
____ 19. Na	j. sodium
____ 20. 17.1 grains per gallon	k. iron
____ 21. 200 mg/l $CaCO_3$	l. $CaCO_3$ solubility
	m. hard water
	n. soft water
	o. 10 ppm
	p. nitrite
	q. 292 ppm
	r. MCL for nitrate

ANSWERS TO STUDENT SELF-CHECK

1. FALSE
2. TRUE
3. FALSE
4. TRUE
5. TRUE
6. b
7. c
8. c
9. d
10. i
11. b
12. e
13. c
14. g
15. d
16. h
17. k
18. l
19. j
20. q
21. m

FINAL CHECKOUT

	YES	NO
1. Listed four units of concentration and explained each.	___	___
2. Related various units of concentration to each other.	___	___
3. Defined given terms.	___	___
4. Discussed periodic table, identifying chemical symbols, names, rows and columns.	___	___
5. Described characteristics and properties of various elements as they related to a waterworks operator.	___	___
6. Identified various chemical compounds by names and by symbols.	___	___
7. Described characteristics and properties of given compounds as they related to a waterworks operator.	___	___
8. Explained the principals of corrosion.	___	___
9. Identified methods to control corrosion.	___	___
10. Defined pH and explained its importance to waterworks plant operators.	___	___

	YES	NO
11. Listed pH ranges for given substances.	___	___
12. Defined and described alkalinity.	___	___
13. Discussed the Baylis curve.	___	___
14. Interpreted Baylis curve using given information.	___	___
15. Defined and described water hardness, including carbonate and non-carbonate hardness.	___	___
16. Discussed problems hardwater can create for the utility and customer.	___	___
17. Identified hardness concentrations for soft and hard water.	___	___
18. Listed two methods of water softening and explained how each works.	___	___
19. Discussed the problem of acid rainfall.	___	___

CHEMICAL ADDITION

Introduction:

Throughout this century, advances in chemistry have produced numerous additives which when added to water yield safe, sanitary, even beneficial (healthful) drinking water. Use of these additives, however, requires a skilled operator who is aware of their properties, because an overabundance can cause more harm than good. This module looks at four of the more popular chemical additives in the waterworks industry: chlorine, fluoride, polyphosphates, and sodium hydroxide.

Chlorine was first used in American to kill waterborne disease organisms in 1908. Since then, chlorine has rapidly been adopted by most water utilities as an effective and economical means of water disinfection. Chlorine has also been used to aid in the removal of iron, manganese, objectionable tastes and odors, and even hydrogen sulfide. Today, however, chlorine has been questioned by some researchers as a safe means of disinfection. This concern arises from the fact that chlorine can react with certain organic substances in water to form chlorinated organic compounds which are suspected or known to be hazardous to human health. Most water supplies in Wisconsin have limited concentrations of organic matter thus chlorination will continue to function as a safe effective means of disinfection here. Conditions may be different in other states.

Fluoridation of public water supplies started in 1945. Since then, over thirty years of practical experience and decades of research have shown that fluoridation of public water supplies is an effective, economical, and safe way to prevent tooth decay. Studies in various parts of the United States indicate that tooth decay can be reduced up to 65% when fluoridated water is consumed during the years of tooth development. Yet fluorine is a very potent element and fluorides, like many other compounds, are safe when properly controlled but can be dangerous when used carelessly. Over the years, fluoridation has been opposed by some people whose arguments have been similar to those used in opposition to polio and smallpox vaccinations, and pasteurization of milk. Even though some people remain opposed to fluoridation, the courts have upheld it as an effective, safe, public health practice and fluoridation has been endorsed by the American Water Works Association, the

Introduction (continued): United States Environmental Protection Agency, the American Dental Association, the American Medical Association and many others.

Polyphosphates (sodium hexametaphosphate, trisodium polyphosphate, and special blends) are added to water to sequester (tie up) low concentrations of iron and prevent them from precipitating out of solution. Generally polyphosphate usefulness, is limited to iron concentrations of less than 1 mg/l with some exceptions. Concentrations greater than this must be removed by other means (oxidation and filtration).

Sodium hydroxide is added to stabilize corrosive-aggressive water. Indexes such as the Langelier Index or Baylis curve are often used to determine corrosiveness. There is no set feed rate for sodium hydroxide, rather the feeder must be adjusted until the desired results are obtained.

Objectives:

1. STATE the principal purpose for the chlorination of water.
2. LIST additional uses of chlorine.
3. IDENTIFY various forms in which chlorine is available and LIST approximate percent available chlorine for each form.
4. DESCRIBE the physical properties of chlorine gas (color, density, and odor).
5. DISCUSS the chemical properties of chlorine gas with respect to its corrosiveness in the presence and absence of moisture.
6. LIST three principal containers chlorine gas is shipped in.
7. EXPLAIN how chlorine gas cylinders should be stored.
8. DESCRIBE a method for detecting chlorine gas leaks.
9. EXPLAIN why gas masks are kept near but not in the chlorinator room.
10. DISCUSS limitations of a canister gas mask and a self contained breathing apparatus.
11. EXPLAIN why the exhaust fan intake is located near the floor in a chlorinator room.

Objectives (continued):

12. DESCRIBE the physical properties of sodium hypochlorite.

13. DISCUSS the storage of sodium hypochlorite.

14. DESCRIBE the physical properties of calcium hypochlorite.

15. DISCUSS the storage of calcium hypochlorite.

16. DEFINE the following terms: chlorine demand, free chlorine residual, combined chlorine residual, total chlorine residual, chloramines.

17. DESCRIBE what happens when chlorine reacts with water.

18. EXPLAIN the principals of breakpoint chlorination and DRAW a breakpoint chlorination diagram.

19. DESCRIBE the effects of the following on the disinfection ability of chlorine:

    a. time of contact
    b. water temperature
    c. pH
    d. type of chlorine residual

20. DESCRIBE first aid procedures when the following symptoms result from the presence of chlorine:

    a. mild throat irritation
    b. eyes irritated by chlorine
    c. areas of skin splashed by chlorine
    d. stopped breathing

21. DISCUSS the effect drinking water containing proper amount of fluoride has on teeth during the years that teeth are forming.

22. DESCRIBE the effect on teeth of drinking water containing a fluoride content greater than the MCL during the years of tooth development.

23. LIST methods of fluoride addition.

24. LIST compounds which are used as fluoride additives.

Objectives (continued):

25. IDENTIFY levels of fluoride in respect to:

    a. acceptable range
    b. optimum level
    c. MCL

26. LIST protective equipment and clothing required when handling dry fluoride compounds.

27. EXPLAIN the purpose for adding polyphosphates to water.

28. IDENTIFY conditions which must be met if iron is to be sequestered with polyphosphates.

29. DISCUSS problems with the use of polyphosphates.

30. EXPLAIN the purpose of adding sodium hydroxide to water.

Learning Activities:

1. READ Chapters 5 and 9, AWWA Manual M18, and pages 126-128, AWWA Manual M21.

2. LISTEN to presentation on chemical addition.

3. VIEW PPG Industries film, "Chlorine Safe Handling."

4. EXAMINE PPG Industries pamphlet, "Chlorine Safe Handling."

5. EXAMINE Department of Health and Social Services Fluoridation Literature.

6. COMPLETE Worksheet.

7. COMPLETE Student Self-check and CHECK answers.

8. PROCEED to Final Check-out.

WORKSHEET

1. What is the principal purpose for the chlorination of water?

2. List three additional uses of chlorine.

   (1) _____

   (2) _____

   (3) _____

3. Chlorine is available in three forms. List and give an example of each.

	Form	Example
(1)		
(2)		
(3)		

4. List the approximate percent of available chlorine for each form listed.

	Form	Percent Available Chlorine
(1)		
(2)		
(3)		

5. What color is chlorine gas?

6. Is chlorine gas heavier or lighter than air?

7. Does chlorine gas have an odor? If so, what does it smell like?

_____

_____

8. Is chlorine gas corrosive by itself?

_____

9. What happens when chlorine gas comes in contact with water vapor? Are any of the by-products corrosive?

_____

_____

10. Chlorine gas is shipped in three principal containers. Name them.

(1) _____

(2) _____

(3) _____

11. How are chlorine gas cylinders stored? (laying on their sides? upright? held by chains? other?)

_____

_____

12. One method to detect chlorine leaks is to use a rag dipped in ammonia or an ammonia bottle. Explain how this works.

_____

_____

13. Why are gas masks kept outside the chlorine room?

_____

_____

14. The canister-type mask utilizes a canister through which incoming air passes. This canister contains a chemical which absorbs the contaminated chlorinated air. What are the limitations of a canister gas mask in a chlorine leak?

15. The self-contained breathing apparatus uses a refillable compressed air tank. What are the limitations of this type of respiratory protection in a chlorine leak?

16. Which form of respiratory protection is more reliable?

17. Why is the exhaust fan intake located near the floor in the chlorine room?

18. What are the physical properties of sodium hypochlorite?

19. Where should sodium hypochlorite be stored?

20. What are the physical properties of calcium hypochlorite?

21. Where should calcium hypochlorite be stored?

_____

_____

_____

22. Define the following terms:

chlorine demand _____

_____

free chlorine residual _____

_____

combined chlorine residual _____

_____

total chlorine residual _____

_____

chloramines _____

_____

23. What happens when chlorine reacts with water?

24. How is disinfection accomplished?

_____

_____

_____

25. What is breakpoint chlorination? What happens in breakpoint chlorination?

_____

_____

_____

26. Draw a diagram to illustrate breakpoint chlorination.

27. Describe the effect each of the following has on the disinfection ability of chlorine.

time of contact _____

_____

water temperature _____

_____

pH _____

_____

type of residual _____

_____

28. Explain what first aid measures you would use on victims of the following chlorine incidents.

mild throat irritation _____

_____

eyes irritated with chlorine _____

_____

areas of skin splashed with liquid chlorine _____

_____

stopped breathing _____

_____

29. What effect does drinking fluoridated water containing the optimum level of fluoride have on teeth during the years that teeth are being formed?

_____

_____

_____

30. What effect does fluoridated water with a fluoride content greater than the MCL have on teeth during the years teeth are forming?

_____

_____

31. List four methods of obtaining fluoride in drinking water.

(1) _____

(2) _____

(3) _____

(4) _____

32. List three compounds water utilities use to add fluoride to drinking water.

(1) _____

(2) _____

(3) _____

33. Identify the following fluoride levels.

	Level ppm
acceptable range	
optimum level	
MCL	

34. What sections of Wisconsin have naturally fluoridated water with concentrations greater than .7 ppm?

_____

_____

35. What effect does temperature have on the addition of fluoride?

_____

_____

36. What special equipment or clothing is needed when handling fluoride powder and liquid?

_____

_____

_____

37. What are polyphosphates used for?

_____

_____

38. What conditions must be met if polyphosphates are to sequester (tie up) iron and prevent it from precipitating?

39. What problem may arise from the use of polyphosphate?

49. What is one way to control this problem (Question #39)?

41. Briefly explain the purpose of adding sodium hydroxide to water.

STUDENT SELF-CHECK

1. Chlorine is lighter than air and tends to rise. TRUE or FALSE?

2. In some localities, fluoride occurs naturally and need not be added to public water to prevent tooth decay in children. TRUE or FALSE?

3. Chloramines are a more powerful disinfecting agent than free chlorine. TRUE or FALSE?

4. Canister masks are more reliable than self-contained breathing apparatus. TRUE or FALSE?

5. A chlorine test kit should be used to locate chlorine gas leaks. TRUE or FALSE?

6. Sodium hydroxide is used to control:

   a. bacteria in water
   b. iron in water
   c. corrosive water
   d. tooth decay

7. Protective devices for operators handling fluoride include:

   a. face masks
   b. goggles
   c. aprons
   d. dust evacuators
   e. all of the above

8. Water with a fluoride content greater than the MCL which is consumed during the tooth developing years will result in:

   a. baldness
   b. mottling or fluorosis
   c. hypertension
   d. heart disease

9. Chlorine is a _____ at ordinary temperatures and pressures:

   a. blue gas
   b. greenish - yellow gas
   c. black - brown gas
   d. solid

10. Polyphosphates are used to:

   a. sequester iron
   b. stabilize corrosive water
   c. disinfect water
   d. prevent tooth decay

11. The correct range (in ppm) for fluoride in Wisconsin drinking water is:

   a. 0.1/0.5
   b. 1.0/1.5
   c. 1.0/5.0
   d. 5.0/10.0

12. Calcium hypochlorite has approximately _____ percent available chlorine:

   a. 70%
   b. 100%
   c. 5%
   d. 15%

13. Which of the following does <u>not</u> result in more effective disinfection?

   a. lower pH
   b. colder water
   c. longer contact time
   d. free residual

14. The proper first aid procedure for a mild throat irritation due to chlorine gas exposure is:

   a. drinking milk
   b. gargling with salt water
   c. a Certs mint
   d. flushing thoroughly with water

ANSWERS TO STUDENT SELF-CHECK

1.	FALSE	8.	b
2.	TRUE	9.	b
3.	FALSE	10.	a
4.	FALSE	11.	b
5.	FALSE	12.	a
6.	c	13.	b
7.	e	14.	a

FINAL CHECKOUT

		YES	NO
1.	Stated principal purpose for chlorination of water.	___	___
2.	Listed additional uses of chlorine.	___	___
3.	Identified various forms in which chlorine is available and listed approximate percent available chlorine for each.	___	___
4.	Described physical properties of chlorine gas.	___	___
5.	Discussed chemical properties of chlorine gas with respect to corrosiveness.	___	___
6.	Listed the three principal containers chlorine gas is shipped in.	___	___
7.	Explained how chlorine gas cylinders should be stored.	___	___
8.	Described a method for detecting chlorine gas leaks.	___	___
9.	Explained why gas masks are kept near but not in the chlorinator room.	___	___
10.	Discussed limitations of respiratory equipment.	___	___
11.	Explained why exhaust fan intake is located near the floor in a chlorinator room.	___	___
12.	Described physical properties of sodium hypochlorite.	___	___

		YES	NO
13.	Discussed the storage of sodium hypochlorite.	___	___
14.	Described the physical properties of calcium hypochlorite.	___	___
15.	Discussed the storage of calcium hypochlorite.	___	___
16.	Defined given terms.	___	___
17.	Described the reaction between chlorine and water.	___	___
18.	Explained principals of breakpoint chlorination and drew breakpoint chlorination diagram.	___	___
19.	Described the effects of given factors on the disinfection ability of chlorine.	___	___
20.	Described first aid procedures for given symptoms resulting from the presence of chlorine gas.	___	___
21.	Discussed the effect drinking water containing proper amount of fluoride has on teeth during the years teeth are forming.	___	___
22.	Described effect on teeth of drinking fluoridated water containing concentrations greater than the MCL during teeth forming years.	___	___
23.	Listed methods of fluoride addition.	___	___
24.	Listed compounds used for fluoride addition	___	___
25.	Identified given fluoride levels.	___	___
26.	Listed protective equipment and clothing required when handling dry fluoride compounds.	___	___
27.	Explained the purpose for adding polyphosphates to water.	___	___
28.	Identified conditions which must be met if iron is to be sequestered with polyphosphates.	___	___
29.	Discussed problems with the use of polyphosphates.	___	___
30.	Explained the purpose of adding sodium hydroxide to water.	___	___

CHEMICAL FEED EQUIPMENT

Introduction:

Some water utilities are fortunate enough to have a source of supply that is both bacteriologically safe and aesthetically pleasing. Many utilities, however, must treat their supply through some form of chemical addition to insure its safety or drinkability. The means by which various chemicals are added to the water supply varies markedly from one utility to another. Dry chemical feeders generally use volumetric or gravimetric principals to dispense additives, whereas liquid chemical feeders generally use positive displacement pumps. Gas feeders commonly use pressure-reducing valves activated by orifices to control the flow rate of gas from pressurized cylinders. However, the objective of all chemical feeders is the same, to dispense some substance into the water supply. This module discusses common types of chemical feeders in terms of operation and maintenance.

Objectives:

1. LIST three chemicals used for chlorinating public water supplies and EXPLAIN how each is introduced into the water supply.

2. From a sketch, IDENTIFY and STATE the functions of the following components of a hypochlorination system:

   a. hypochlorite solution container
   b. suction line with strainer
   c. diaphragm type positive displacement pump
   d. motor
   e. discharge line
   f. discharge line check valve
   g. injector connection

3. DESCRIBE the operation of a mechanically actuated diaphragm positive displacement pump.

4. DESCRIBE the operation of a hydraulically actuated diaphragm positive displacement pump.

5. LIST four points to be considered in positioning a hypochlorite pump.

6. DESCRIBE how pump capacity can be controlled by: (a) length of stroke and (b) number of strokes.

Objectives (continued):

7. IDENTIFY suitable injection points for hypochlorites.

8. IDENTIFY problems encountered with positive displacement pumps used for feeding hypochlorites.

9. OUTLINE a preventive maintenance program for a positive displacement pump feeding hypochlorites.

10. DESCRIBE the operation of a solution-feed vacuum type gas chlorination setup.

11. Given a sketch of a solution feed gas chlorination system, IDENTIFY and STATE the function of the following components:

    a. chlorine gas cylinder
    b. yoke unit
    c. control unit (chlorinator)
    d. gas vacuum line
    e. booster pump and piping
    f. injector
    g. exhaust fan switch

12. DESCRIBE the proper procedure for connecting gas cylinders to chlorination system using a yoke clamp.

13. EXPLAIN why lead or asbestos washers are never reused.

14. DESCRIBE proper procedure for connecting cylinder mounted chlorinators.

15. LIST suitable pipe materials to be used with chlorine gas.

16. DESCRIBE the correct procedure to open cylinder valve.

17. EXPLAIN why valves should never be operated in such a manner as to isolate chlorine gas or liquid in a line.

18. DESCRIBE correct method for closing cylinder valve when cylinder is empty.

19. DISCUSS various methods to control feed rate for gas chlorination systems.

20. Given necessary data, CALCULATE dosages for sodium hypochlorite, calcium hypochlorite, and gas chlorine.

Objectives (continued):

21. DIFFERENTIATE between gravimetric and volumetric dry feeders.
22. SKETCH a volumetric feed system with solution tank.
23. EXPLAIN the need for using soft water in fluoride feeders.
24. From a sketch, IDENTIFY and STATE the functions of the components of a direct acid (fluoride) feed system.
25. DISCUSS when a diluted acid feed system is used and LIST additional pieces of equipment needed.
26. DISCUSS effect fluosilicic acid fumes have on other materials.
27. SKETCH a fluoride saturator setup showing: water softener, water meter, tank, sodium fluoride bed, metering pump, and discharge piping.
28. OUTLINE a preventive maintenance program for one of the the three fluoride systems previously discussed.

Learning Activities:

1. READ Chapter 6, AWWA Manual M18.
2. LISTEN to chemical feed equipment presentation.
3. VIEW chemical feed equipment slide presentation.
4. EXAMINE sample chemical feeders.
5. COMPLETE Worksheet.
6. COMPLETE Student Self-check and CHECK answers.
7. PROCEED to Final Checkout.

WORKSHEET

1. List three chemicals commonly used for chlorinating public water supplies.

   (1) _____

   (2) _____

   (3) _____

2. How is each of the chemicals listed in Question #1 introduced into the water supply?

   (1) _____

   _____

   _____

   (2) _____

   _____

   _____

   (3) _____

   _____

   _____

3. Using the sketch on the following page, identify the components of a hypochlorination system and state the function of each:

   hypochlorite solution container _____

   _____

   suction line with strainer _____

   _____

   diaphragm type positive displacement pump _____

   _____

motor _____

_____

discharge line _____

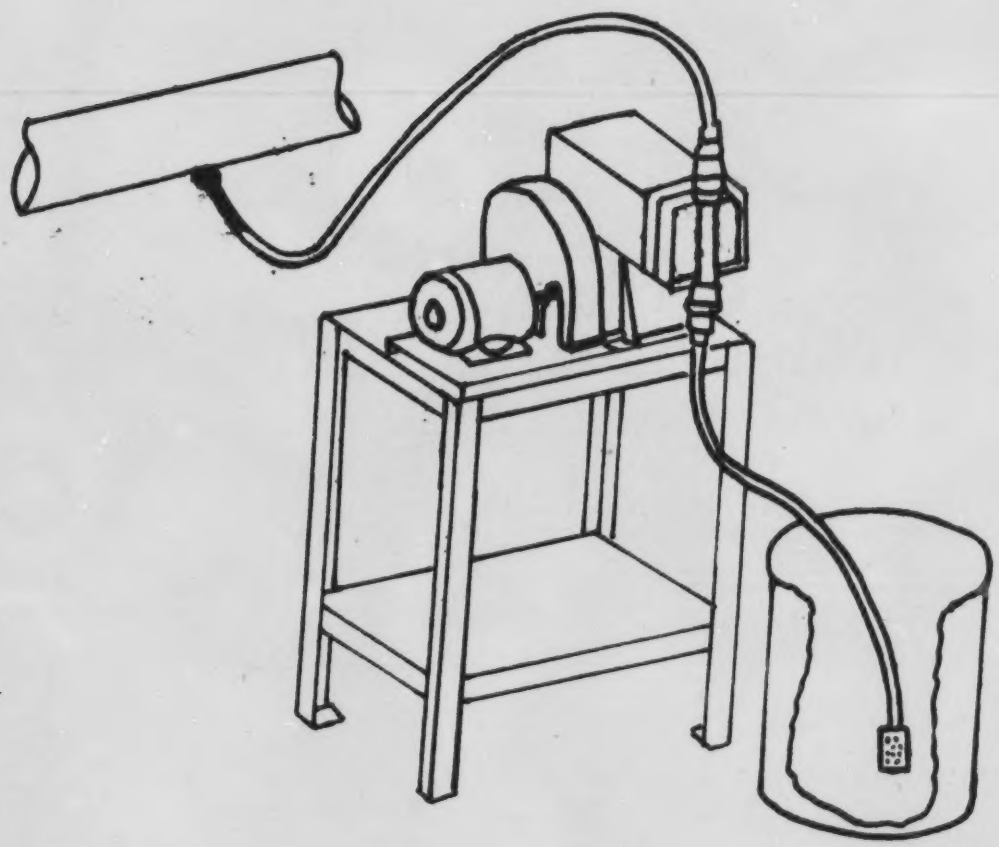
_____

discharge line check valve _____

_____

injector connection _____

_____



150

4. In your own words, describe how a mechanically actuated diaphragm positive displacement pump works.

_____

_____

_____

5. In your own words, explain how a hydraulically actuated diaphragm positive displacement pump works.

_____

_____

_____

6. What are four points to be considered when determining where to set up a hypochlorite pump?

(1) _____

(2) _____

(3) _____

(4) _____

7. Explain how pump capacity (output) can be controlled by the following.

length of stroke _____

_____

_____

number of strokes _____

_____

_____

8. Where should hypochlorite injection points be located? Explain your reasons.

_____

_____

_____

9. What problems are generally encountered with positive displacement pumps used for hypochlorite feeders?

10. Outline a preventive maintenance program for positive displacement pumps feeding hypochlorites.

11. How does a solution-feed vacuum type chlorinator work?

12. From the sketch on the following page, identify the components listed and state the function of each.

    a. chlorine gas cylinder _____

    b. yoke unit _____

    c. chlorinator _____

    d. gas vacuum line _____

e. booster pump _____

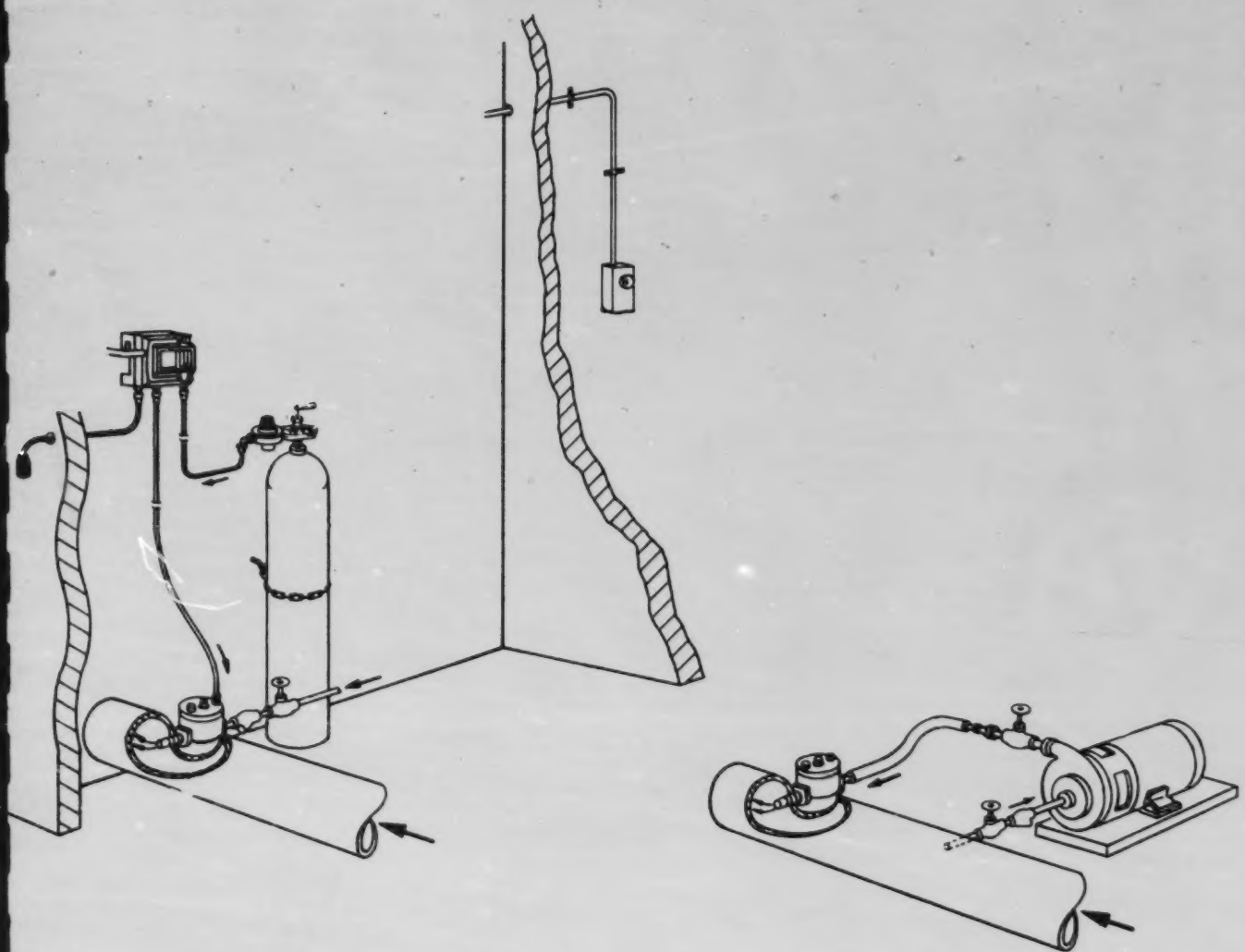
_____

f. injector _____

_____

g. exhaust fan switch _____

_____



13. In your own words, describe how to connect the yoke unit to a chlorine cylinder.

14. Why are lead or asbestos washers never reused?

15. What is the correct procedure for connecting a cylinder-mounted chlorinator?

16. What materials can be used for piping chlorine gas?

17. What is the correct procedure for opening a chlorine gas cylinder valve? How should your body be positioned?

18. Why is it important not to isolate chlorine gas in the vacuum line when closing the cylinder valve?

19. Describe in your own words the correct method for closing the cylinder valves when the chlorine cylinder is empty.

20. List three methods to control the feed rate for gas chlorination systems and explain each.

(1)

(2)

(3)

21. Using the given information, calculate dosages for sodium hypochlorite, calcium hypochlorite, and gas chlorine.

22. What is the difference between a gravimetric dry feeder and a volumetric dry feeder?

23. Sketch a volumetric fluoride feed system with a solution tank showing:

a. water supply
b. rotameter for water supply
c. volumetric feeder and hopper
d. solution tank
e. air gap between solution tank and solution discharge piping
f. solution discharge piping
g. mixing equipment

24. Why is it important to use soft water with fluoride feeders?

25. From the following sketch of a direct acid (fluoride) feed system, identify the components listed and state their functions.

a. acid shipping drum _____

_____

b. platform scale _____

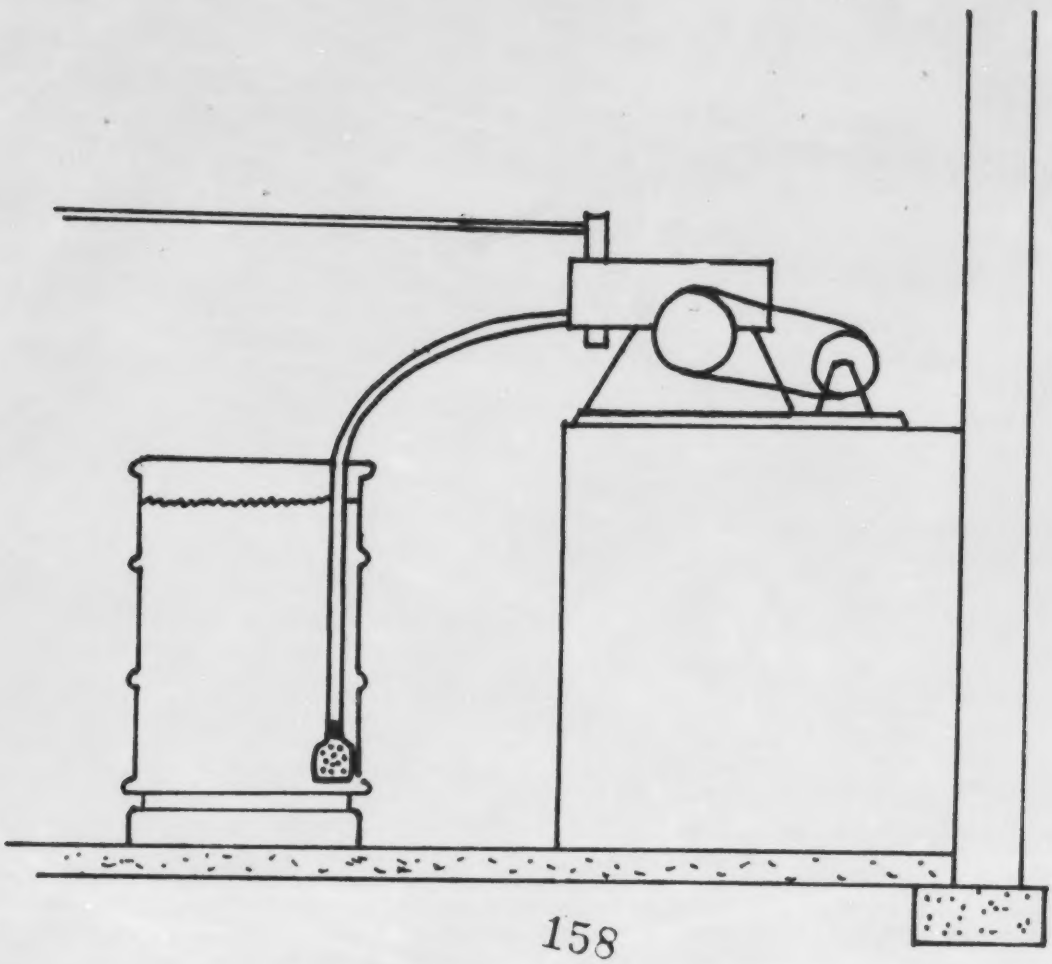
_____

c. metering pump _____

_____

d. anti-siphon valve _____

_____



158

26. Where might a diluted acid feed system be used?

_____

_____

27. What additional equipment (other than that in Question #26) would be used for a diluted acid feed system?

_____

_____

_____

28. What effect does fluosilicic acid have on the following:

glass _____

_____

_____

metal _____

_____

_____

29. Sketch a fluoride saturator setup showing:

a. water softener
b. water meter
c. tank
d. sodium fluoride bed
e. metering pump
f. discharge piping

30. Outline a preventive maintenance program for one of the three (volumetric, direct feed, saturator) fluoride feed systems.

STUDENT SELF-CHECK

____ 1. Chlorine gas is usually fed with a positive displacement pump. TRUE or FALSE?

____ 2. Chlorine gas cylinders should be opened one full turn. TRUE or FALSE?

____ 3. Hypochlorite feed lines clogged with calcium and magnesium deposits can be cleaned using sulfuric acid. TRUE or FALSE?

____ 4. Lead or asbestos washers may be reused on gas chlorination systems. TRUE or FALSE?

____ 5. An injection nozzle at the point of chemical application will give a better distribution of the chemical than a corporation. TRUE or FALSE?

____ 6. A positive displacement pump is one which:

a. has a rotating impeller
b. pumps a set volume with each stroke
c. feeds the chemical as a dry powder
d. none of the above

____ 7. An anti-siphon device is used to:

a. control the amount of chemical fed
b. keep the feeder operating at all times
c. prevent chemical suck back through the pump
d. none of the above

____ 8. Chemical feeders feeding chlorine gas should be located:

a. anywhere convenient
b. in a basement
c. in a separate room
d. outside the pumphouse

____ 9. Which of the following factors would <u>not</u> change the amount of chemical added to the system by a positive displacement pump?

a. length of pushrod stroke
b. number of strokes per minute
c. concentration of solution being fed
d. diameter of feed line

____ 10. Internal components of a feeder which come in contact with chemical being fed should be made:

a. of material which is resistant to the chemical
b. with one piece construction so it won't leak
c. of gray cast iron
d. none of the above

ANSWERS TO STUDENT SELF-CHECK

1.	FALSE	6.	b
2.	TRUE	7.	c
3.	FALSE	8.	c
4.	FALSE	9.	d
5.	TRUE	10.	a

FINAL CHECKOUT

		YES	NO
1.	Listed three chemicals used for chlorinating public water supplies and explained how each is introduced into the water supply.	___	___
2.	Identified and stated functions of the components of a hypochlorite feed system.	___	___
3.	Described the operation of a mechanically actuated diaphragm positive displacement pump.	___	___
4.	Described the operation of a hydraulically actuated diaphragm positive displacement pump.	___	___
5.	Listed four points to be considered in positioning a hypochlorite pump.	___	___
6.	Described how pump capacity can be controlled by length of stroke and number of strokes.	___	___
7.	Identified injection points for hypochlorite solutions.	___	___
8.	Identified problems encountered with positive displacement pumps used for feeding hypochlorites.	___	___
9.	Outlined a preventive maintenance program for a positive displacement pump feeding hypochlorites.	___	___
10.	Described the operation of a solution-feed vacuum type gas chlorination system.	___	___

		YES	NO
11.	Identified and stated functions of given components of gas chlorination system.	___	___
12.	Described proper procedure for connecting gas cylinders to chlorination system using a yoke clamp.	___	___
13.	Explained why lead or asbestos washers are never reused.	___	___
14.	Described proper procedure for connecting cylinder mounted chlorinators.	___	___
15.	Listed pipe materials suitable for use with chlorine gas.	___	___
16.	Described correct procedure to open cylinder valves.	___	___
17.	Discussed importance of never operating valves so as to isolate chlorine gas or liquid in a line.	___	___
18.	Described correct method for closing cylinder valve when cylinder is empty.	___	___
19.	Discussed various methods to control the feed rate for gas chlorination systems.	___	___
20.	Calculated dosages for hypochlorite and gas chlorine problems.	___	___
21.	Differentiated between gravimetric and volumetric dry feeders.	___	___
22.	Sketched a volumetric feed system.	___	___
23.	Explained the need for using soft water in fluoride feeders.	___	___
24.	From a sketch of a direct acid feed system, identified given components and stated their functions.	___	___
25.	Discussed when a diluted acid feed system is used and listed additional pieces of equipment needed.	___	___
26.	Discussed effect fluosilicic acid fumes have on other materials.	___	___
27.	Sketched a fluoride saturator system.	___	___
28.	Outlined a preventive maintenance program for one of three fluoride systems previously discussed.	___	___

BACTERIOLOGY

Introduction:

The use of bacteria to determine water quality dates back some time. Today, bacteria from the coliform group, principally Escherichia coli and enterobacter are the chief biological indicators of water pollution. The level of all coliform bacteria, collectively known as "total coliform," is the recognized criterion for the sanitary quality of water.

Coliform bacteria are useful indicators of contamination because they are found alongside other bacteria responsible for such diseases as cholera, dysentery, and typhoid fever while being relatively harmless organisms themselves. Furthermore, coliform bacteria are good indicators because they survive longer than pathogenic (disease-producing) bacteria and are easier to isolate and identify.

In order to insure that water being supplied to the public is safe, operators must collect representative water samples from the distribution system and have those samples analyzed for coliform bacteria at a certified laboratory. Proper sampling techniques must be followed to the letter to prohibit unwanted bacteria from entering the sample (hence inaccurate results). This module examines a good bacteriological sampling program, explains the correct procedure for collecting a bacteriological sample, examines pitfalls in filling out a bacteriological report form, and discusses the procedure for bacteriological testing.

Objectives:

1. DESCRIBE a good bacteriological sampling program.
2. IDENTIFY types of faucets or taps from which a bacti sample should not be taken.
3. IDENTIFY suitable bacti sampling sites.
4. LIST the requirements for a bottle to be used in collecting a bacti sample from a chlorinated distribution system and a non-chlorinated distribution system.

Objectives (continued):

5. DESCRIBE the correct procedure for collecting a bacti sample relative to:

   a. flushing the tap or faucet
   b. flaming the tap or faucet
   c. opening and closing the bottle
   d. filling the bottle

6. IDENTIFY problems arising from flaming a tap or faucet.

7. STATE how long a bacti sample can be held before testing.

8. DESCRIBE the method of preservation for bacti samples.

9. IDENTIFY places where bacti samples may be analyzed.

10. IDENTIFY form to use when submitting a bacti sample from a public water supply system.

11. LIST common mistakes made in filling out a bacti form.

12. DESCRIBE procedure to follow when a sample is "unsafe."

13. DESCRIBE procedure to follow if check sample is "unsafe."

14. DIFFERENTIATE between coliform bacteria and pathogens.

15. LIST reasons coliform bacteria are good indicating organisms.

16. DESCRIBE procedure for the MF total coliform test.

17. IDENTIFY other test methods for total coliform testing.

18. CITE advantages of the MF method over the MPN method of testing for total coliform levels.

19. LIST MCL levels for bacteria.

Learning Activities:

1. READ Chapter 11, AWWA Manual M18, pages 19-21, ("Collection of Water Samples for Analysis" through "Frequency of Sampling").

2. SKIM remaining parts of Chapter 11, AWWA Manual M18.

3. LISTEN to presentation on bacteriology.

4. EXAMINE sample bacti bottles.

5. COLLECT bacti sample from suitable location.

6. VIEW Millipore slide presentation on the MF total coliform test.

7. COMPLETE Worksheet.

8. COMPLETE Student Self-check and CHECK answers.

9. PROCEED to Final Checkout.

WORKSHEET

1. List three points involved in a good bacteriological sampling program.

   (1) _____

   _____

   (2) _____

   _____

   (3) _____

   _____

2. Some water utilities install special sample taps from which bacti samples are collected. Most facilities don't have this feature however, and must sample elsewhere. List four locations from which a bacti sample should not be taken.

   (1) _____

   (2) _____

   (3) _____

   (4) _____

3. Describe (in your own words) the type of faucet a bacti sample should be taken from.

   _____

   _____

   _____

4. What are the requirements for a bottle to be used in collecting a bacti sample from a non-chlorinated distribution system?

   _____

5. What are the requirements for a bottle to be used in collecting a bacti sample from a chlorinated distribution system?

6. Describe (in your own words) the correct procedure for collecting a bacti sample.

7. Why should you flush a tap or faucet before collecting a bacti sample?

8. How long should an operator flush the tap before collecting the sample?

9. The Department of Natural Resources advises flaming a tap before collecting a bacti sample. Identify some problems which may arise from flaming a tap or faucet too long.

10. When collecting a bacti sample, it is important not to touch certain parts of bacti bottle. List these.

_____

_____

_____

11. How long can a bacti sample be held before testing?

_____

_____

12. If a bacti sample cannot be analyzed right away, what is the best method for preserving the sample?

_____

13. Where may bacti samples be analyzed?

_____

_____

14. When submitting a bacti sample from a public water supply system, what form must be completed and sent along with it?

_____

15. In filling out this form (Question #14), operators often make mistakes. List three of the more common mistakes.

(1) _____

_____

(2) _____

_____

(3) _____

_____

16. What must an operator do if a bacti sample comes back "unsafe"?

_____

_____

17. What must an operator do if a check sample comes back "unsafe?"

_____

_____

_____

18. What is the difference between coliform bacteria and pathogenic bacteria?

_____

_____

19. Coliform bacteria are good indicators of contamination for a variety of reasons. List two.

_____

_____

_____

20. Briefly summarize the MF test procedure for total coliform analysis.

21. What other test methods are used for total coliform analysis?

_____

_____

22. List two advantages of the MF method over the MPN method of testing for total coliform bacteria.

_____

_____

23. What are the MCL's for coliform bacteria in regard to the MF test and the MPN test?

_____

_____

_____

STUDENT SELF-CHECK

___ 1. Bacteriological examinations of water are made to determine its suitability for drinking and general use. TRUE or FALSE?

___ 2. The blue bacti form should be completed when collecting a bacti sample from a public water supply system. TRUE or FALSE?

___ 3. A sterilized bottle containing sodium thiosulfate should be used to collect a bacti sample from a chlorinated distribution system. TRUE or FALSE?

___ 4. Touching the bacti bottle lip or inner cap has no effect on the accuracy of the sample. TRUE or FALSE?

___ 5. Bacti samples must be analyzed at laboratories certified by the Department of Health and Social Services or at the State Laboratory of Hygiene. TRUE or FALSE?

___ 6. Bacti bottles should be filled

a. half-way full
b. filled to ½" of the top
c. completely full
d. doesn't matter

___ 7. Bacti samples should be collected from

a. threaded faucets
b. faucets with screens
c. smooth bore faucets
d. none of the above

___ 8. To get the best results, bacti samples should be submitted within _____ hours, run by _____ hours, with _____ hours as a maximum allowable time before testing.

a. 12/24/36
b. 18/28/38
c. 24/30/48
d. 24/48/72

___ 9. A good bacti sampling program includes:

a. collecting samples at different locations throughout the month using a network of suitable sampling points
b. varying sample times whenever possible
c. aseptic sampling procedures
d. all of the above

___ 10. When collecting a bacti sample, an operator should

a. sterilize the tap by heating
b. run the water several minutes before sampling
c. rinse out the bacti bottle before sampling
d. all of the above
e. only a and b

ANSWERS TO STUDENT SELF-CHECK

1. TRUE	6. b
2. TRUE	7. c
3. TRUE	8. c
4. FALSE	9. d
5. TRUE	10. e

FINAL CHECKOUT

	YES	NO
1. Described a good bacteriological sampling program.	___	___
2. Identified types of faucets or taps from which a bacti sample should not be taken.	___	___
3. Identified suitable bacti sampling sites.	___	___
4. Listed the requirements for a bottle to be used in collecting a bacti sample from a chlorinated distribution system and a non-chlorinated distribution system.	___	___
5. Described the correct procedure for collecting a bacti sample.	___	___
6. Identified problems arising from flaming a tap or faucet.	___	___
7. Stated how long a bacti sample can be held before testing.	___	___
8. Described the method of preservation for bacti samples.	___	___
9. Identified places where bacti samples may be analyzed.	___	___
10. Identified form to use when submitting a bacti sample from a public water supply system.	___	___
11. Listed common mistakes made in filling out a bacti form.	___	___
12. Described procedure to follow when a sample is "unsafe."	___	___

		YES	NO
13.	Described procedure to follow if check sample is "unsafe."	___	___
14.	Differentiated between coliform bacteria and pathogenic bacteria.	___	___
15.	Listed reasons coliform bacteria are good indicating organisms.	___	___
16.	Described procedure for the MF total coliform test.	___	___
17.	Identified other test methods for total coliform bacteria.	___	___
18.	Cited advantages of the MF method over the MPN method of testing for total coliform.	___	___
19.	Listed MCL levels for bacteria.	___	___

LABORATORY TESTING

Introduction:

In order to comply with the 1974 Safe Drinking Water Act, many waterworks facilities must adopt a more rigorous water quality monitoring program. Waterworks laboratories are gearing up for this move by investing in new precision time-saving equipment and by training operators in proper laboratory technique. Today's operator must know not only the methodology for each test, but also any interferences involved in the analysis.

This module covers the methodology and interferences for fluoride, chlorine, and pH testing. Proper technique and safety are also emphasized.

Objectives:

1. LIST reasons for laboratory testing.
2. IDENTIFY reference texts on laboratory procedures.
3. LIST laboratory safety equipment and EXPLAIN purpose each serves.
4. EXPLAIN correct way to read a water level meniscus.
5. EXPLAIN the need for clean glassware in laboratory testing and the reason for rinsing out glassware with solution used in it.
6. EXPLAIN how to use a pipet bulb and the reason for using one.
7. OUTLINE the procedure for free and total chlorine residual testing, using either DPD method or amperiometric method.
8. LIST interfering chemicals for test method outlined.
9. DEMONSTRATE test for free and total residual chlorine, using method outlined.
10. OUTLINE the procedure for fluoride testing, using either the SPADNS method or the specific ion method.

Objectives (continued):

11. LIST interfering chemicals for the fluoride test procedure outlined.
12. DEMONSTRATE test for fluoride, using method outlined.
13. OUTLINE test procedure for pH using the electode method.
14. DEMONSTRATE the test for pH using the electrode method.
15. IDENTIFY levels at which fluoride and free and total residual chlorine should be maintained at.
16. IDENTIFY how often chlorine and fluoride levels must be tested.

Learning Activities:

1. READ Chapter 10, M18, pp. 74-80, omitting iron, manganese, and hardness sections.
2. LISTEN to presentation on laboratory testing.
3. DEMONSTRATE ability to use a pipet bulb.
4. DEMONSTRATE ability to perform residual chlorine, fluoride, and pH tests.
5. COMPLETE Worksheet.
6. COMPLETE Student Self-check and CHECK answers.
7. PROCEED to Final Checkout.

WORKSHEET

1. List four reasons a waterworks operator should test the water that is being supplied to the public.

   (1) _____

   (2) _____

   (3) _____

   (4) _____

2. Two of the more common reference texts on laboratory procedures are:

   (1) _____

   (2) _____

3. Each waterworks laboratory should be equipped with laboratory safety equipment. Identify four pieces and explain the purpose of each.

   (1) _____ _____

   (2) _____ _____

   (3) _____ _____

   (4) _____ _____

4. Explain the correct way to read a meniscus.

   _____

   _____

5. Why must clean glassware be used for laboratory testing?

6. It's always (except for bacteriological sampling) a good idea to rinse out glassware and bottles with the solution you are going to use in it. Explain why.

7. How does a pipet bulb work?

8. What is the purpose of using a pipet bulb?

9. Describe the procedure for free and total residual chlorine testing, using either the DPD method or amperiometric method.

180

10. What chemicals (elements or compounds) can interfere in the method outlined?

_____

_____

11. Describe the procedure for fluoride testing, using either the SPADNS method or the specific ion method.

12. What interferences are involved in the procedure you just described?

_____

_____

13. Outline the procedure for pH testing using the electrode method.

14. Groundwater facilities which chlorinate must maintain a free chlorine residual of at least _____ mg/l or a combined chlorine residual of at least _____ mg/l.

15. Groundwater facilities which chlorinate must test the chlorine residual at least _____ from the distribution system.

16. If an operator is adding fluoride, what is the acceptable range it should be maintained in?

_____

17. If an operator is adding fluoride, how often must the fluoride concentration be tested from the distribution system?

_____

18. How often must a fluoride sample be sent to the State Laboratory of Hygiene for analysis?

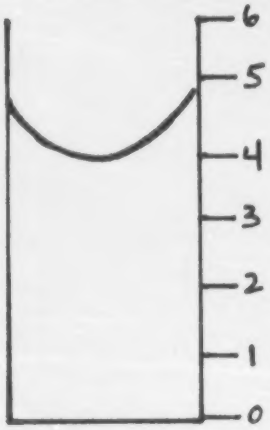
_____

_____

182

STUDENT SELF-CHECK

___ 1.



The water level in the column at the left is:

a. 3
b. 3.5
c. 4
d. 5
e. cannot be determined

___ 2. Which of the following are interferences in the SPADNS test for fluoride?

a. aluminum
b. polyphosphate
c. ferric iron
d. all of the above

___ 3. In the Hach DPD total chlorine test, an operator must allow at least _____ but not more than _____ for color development in the sample before reading the results.

a. 1 hour - 2 hours
b. 30 minutes - 45 minutes
c. 10 minutes - 30 minutes
d. 3 minutes - 6 minutes
e. it is not necessary to wait for color development

___ 4. In the SPADNS test for fluoride, it is important that the sample and standards both be at the same temperature, 20°C. TRUE or FALSE?

___ 5. Simplified Procedures for Water Examination is a good reference text for most waterworks laboratory tests. TRUE or FALSE?

___ 6. In testing for free or total chlorine using the Hach DPD powder pillow method it is imperative that all particles in the powder pillow dissolve in order to obtain an accurate reading. TRUE or FALSE?

____ 7. Always use a pipet bulb or a hand apparatus when using a pipet, because using a pipet like a soda straw often results in the same--a mouthful of the fizzy stuff. TRUE or FALSE?

____ 8. Volume measurements in the fluoride SPADNS test are extremely critical and should be made with a pipet. TRUE or FALSE?

____ 9. When using the Hach DPD free chlorine method, the sample must be read not more than one minute after emptying the reagent in the sample container. TRUE or FALSE?

____ 10. A pH meter should always be standardized before use. TRUE or FALSE?

ANSWERS TO STUDENT SELF-CHECK

1. c
2. d
3. d
4. TRUE
5. TRUE
6. FALSE
7. TRUE
8. TRUE
9. TRUE
10. TRUE

FINAL CHECKOUT

		YES	NO
1.	Listed reasons for laboratory testing.	___	___
2.	Identified reference texts on laboratory procedures.	___	___
3.	Listed laboratory safety equipment and explained purpose each serves.	___	___
4.	Explained correct way to read water level meniscus.	___	___
5.	Explained the need for clean glassware in lab testing and the reason for rinsing out glassware with solution used in it.	___	___
6.	Explained how to use a pipet bulb and the reasons for using one.	___	___
7.	Outlined procedure for free and total chlorine residual testing.	___	___
8.	Listed interfering chemicals for test method outlined.	___	___
9.	Demonstrated test for free and total residual chlorine.	___	___
10.	Outlined procedure for fluoride testing.	___	___
11.	Listed interfering chemicals for the fluoride test method outlined.	___	___
12.	Demonstrated test for fluoride.	___	___

		YES	NO
13.	Outlined test procedure for pH using the electrode method.	___	___
14.	Demonstrated the test for pH using the electrode method.	___	___
15.	Identified levels at which fluoride and free and total residual chlorine should be maintained at.	___	___
16.	Identified how often fluoride and chlorine levels must be tested.	___	___

WATERWORKS MATH

Introduction:

Mathematics is a tool we have all come to depend upon. We use it in almost every professional and non-professional field. In water treatment, good plant operation is dependent upon a number of things and mathematics is involved in almost all of them. Operators use mathematics to determine water levels, calculate pump capacities, set chemical feeders, calculate filter runs, prepare budgets, and many other things.

Often, however, operators and the general public alike find certain mathematical operations difficult or are confused by new mathematical terminology. This module is intended to help refresh your memory and bring you up to date in waterworks math.

Objectives:

1. DESCRIBE the metric system by matching prefixes with correct units of length, area, weight (mass), and volume.
2. IDENTIFY metric units commonly used in the waterworks field.
3. DEFINE weight, length, area, volume, flow and concentration in mathematical terms.
4. IDENTIFY English units of measurement for length, area, weight, volume, flow and concentration.
5. MATCH algebraic and geometric formulas with correct definitions.
6. EXPLAIN and DEMONSTRATE the use of scientific notation and significant figures.
7. SOLVE typical waterworks math problems.

Learning Activities:

1. READ Chapter 4, AWWA Manual M18.
2. EXAMINE sheet of conversion factors.
3. LISTEN to presentation on waterworks math.
4. COMPLETE Worksheet.
5. COMPLETE Student Self-check and CHECK answers.
6. PROCEED to Final Checkout.

WORKSHEET

ALWAYS REMEMBER: When solving any mathematical problem, it pays to be neat, to show your work, and to check your answer.

1. The metric system uses three "root" words to which are attached a number of prefixes to describe weight (mass), length, and volume.

   The basic unit for weight measurement in the metric system is the

   _____.

   The basic unit for length measurement in the metric system is the

   _____.

   The basic unit for volume measurement in the metric system is the

   _____.

2. Prefixes which are then attached to these "root" words are listed below. Match each with its meaning.

____	1. kilo	a.	.1
____	2. hecto	b.	100
____	3. deka	c.	1,000
____	4. deci	d.	.001
____	5. centi	e.	.01
____	6. milli	f.	10

3. Using the prefixes and basic units just described, match the following:

____	1. milligram	a. 1,000 grams
____	2. kilogram	b. .01 meters
____	3. centimeter	c. 1,000 meters
____	4. kilometer	d. .001 grams
____	5. meter	e. 10 decimeters

4. In the metric system a meter is a little longer than a _____, while a liter is a little larger than a _____, and a gram is a little more than the weight of a _____.

5. What metric units are commonly used in the waterworks field? How do these relate to English measurements?

6. Define the following in mathematical terms:

weight _____

_____

length _____

_____

area _____

_____

volume _____

_____

flow _____

_____

concentration _____

_____

7. Match English units of measurement with the following:

____	a. length	1. square miles (mi^2)
____	b. area	2. million gallons per day (mgd)
____	c. weight	3. feet (ft)
____	d. volume	4. cubic feet (ft^3)
____	e. flow	5. parts per million (ppm)
____	f. concentration	6. inches (in)
		7. gallons per minute (gpm)
		8. cubic feet per second (cfs)
		9. gallon (gal)
		10. pound (lb)

8. Match each of the following formulas with the parameter it measures:

KEY

a. volume of a rectangular solid
b. area of a circle
c. area of a rectangle
d. weight in pounds
e. volume of a cylinder
f. volume of a sphere
g. area of a cylinder (sides and top)

____ L x W (length times width)

____ L x W x D (length times width times depth)

____ πR^2 (3.14 times radius squared)

____ $\pi R^2 L$ (3.14 times radius squared times length)

____ $4/3\pi R^3$ (4/3 times 3.14 times radius cubed)

____ ppm x MG x 8.34 (parts per million times million gallons times 8.34)

____ $2\pi RL + \pi R^2$ (2 times 3.14 times radius times length plus 3.14 times radius squared)

9. What do the following mean?

π _____

_____

R _____

_____

R^2 _____

_____

R^3 _____

_____

2R _____

10. Very large and very small numbers are conveniently written by showing the number of 10's that can be factored and writing this as an exponent of 10 (scientific notation).

Write the following numbers in scientific notation.

12,000,000 _____ 46,200 _____

0.0076 _____ 0.040 _____

11. Only significant figures should be used in recording analytical results. Significant figures are only those digits which are known with certainty plus its first uncertain digit. In addition and subtraction, this translates to no more places than the least number involved. In multiplication, this means the answer is recorded to the least number of significant digits used in the calculation.

Calculate the following using significant figures.

a.
$$\begin{array}{r} 2.1 \\ 3.50 \\ +66.02 \\ \hline \end{array}$$

b.
$$\begin{array}{r} 25 \\ +\ 7.2158 \\ \hline \end{array}$$

c.
$$\begin{array}{r} 56.445 \\ 41.446 \\ +\ 3.445 \\ \hline \end{array}$$

d.
$$\begin{array}{r} 4.1 \\ \times\ 11.6 \\ \hline \end{array}$$

b.
$$\begin{array}{r} 5.16 \\ \times\ 20 \\ \hline \end{array}$$

$$\begin{array}{r} 121.4 \\ \times\ .056 \\ \hline \end{array}$$

12. A well pump delivers 200 gpm. How many mgd will it deliver in 24 hours?

13. A cylindrical elevated tower has a height (excluding the legs) of 10 feet and a diameter of 5 feet.

    a. How many gallons of water will it hold when full?

    b. How many pounds does that weigh?

14. Your well house water meter reads 57899 on Monday morning and 83577 on Thursday morning. What is the average daily pumpage?

15. You need a reservoir that can hold at least 5,000 gallons. Is a tank that is 10 feet long, 5 feet wide, and 4 feet deep large enough?

16. You have dug a trench to install a hydrant. It is 8 feet deep 2 feet long and 3 feet wide. Your front loader holds 15 cubic feet at a time. How many times will you need to use it to fill the trench?

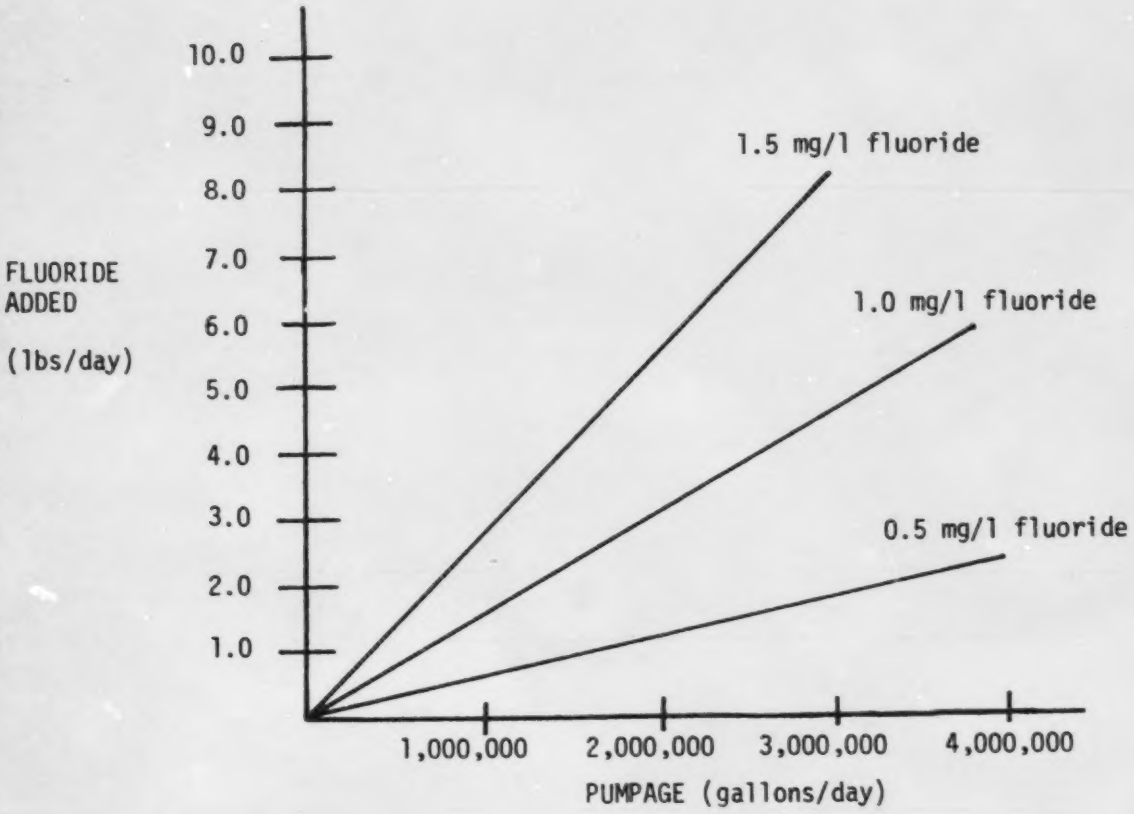
17. The following figures were given to you by the contracter as he finished the well pump installation.

well depth - 660'
pump bowls setting - 404'
air line length - 350'
pressure gage reading when the pump was off - 80 psi
pressure gage reading when the pump was running - 62 psi
pump output when running - 260 gallons per minute

Using this information, calculate the static water level, the pumping water level, the drawdown, and the specific capacity.

18. For the annual budget, the village president wants to know how much fluoride addition is costing the village. You use an average of 1½ pounds per day. What is the annual cost at $1.00 for 10 pounds?

19. Using the graph below, calculate how many pounds of fluoride you need per week to get a fluoride concentration of 1.0 ppm, if your average daily pumpage is 1.0 mgd?



20. A standpipe (cylinder shape) is 15 feet in diameter and 60 feet high. What is the capacity of the standpipe in gallons? If you wish to paint the outside of the standpipe how many square feet of surface area are there to paint?

21. If one gallon of paint costs $5.25 and covers 75 square feet, how much is it going to cost you to paint the standpipe in Question #20 two coats?

22. If an elevated tank has an overflow elevation of 1,500 feet, what is the static pressure in psi when the tank is full at a hydrant outlet located one mile from the tank? (The hydrant outlet has an elevation of 1,300 feet.)

23. Given the following:

    storage reservoir 25' wide, 50' long, and 10' deep,

    How many gallons of water will the reservoir hold?

24. Before putting the reservoir in Question #23 into service, you must disinfect it. You know that one calcium hypochlorite tablet added to 500 gallons of water gives a 100 mg/l chlorine concentration. How many calcium hypochlorite tablets are needed then to disinfect the reservoir in Question #23 to a 50 ppm chlorine concentration?

25. You have recently replaced a 80' section of 10" ductile iron water main. How many pounds of calcium hypochlorite (70% available chlorine) are needed to disinfect this section to a 50 ppm chlorine concentration?

STUDENT SELF-CHECK

____ 1. A ground storage reservoir has the following dimensions--length - 100 feet, width - 50 feet, depth - 12 feet. What is the volume of the reservoir?

a. 60,000 feet
b. 6,000 $feet^3$
c. 60,000 $feet^3$
d. 6,000 feet

____ 2. The formula for the volume of a cylinder is:

a. L x W
b. πR^2
c. $\pi R^2 L$
d. $4/3 \pi R^3$

____ 3. A contractor recently installed 1,000 feet of 8-inch diameter water main. What is the end area (cross-sectional area) of the pipe in square feet?

a. .35 $feet^2$
b. .7 $feet^2$
c. 1.4 $feet^2$
d. none of the above

____ 4. What volume of water (in gallons) will the 1,000 foot length of 8-inch pipe hold?

a. 10,472 gallons
b. 2,919 gallons
c. 2,618 gallons
d. 21,840 gallons

____ 5. 2.34×10^7 is

a. 2,340,000,000
b. 23,400,000
c. 2,340,000
d. none of the above

____ 6. Given a well is 900 feet deep with an air line of 600 feet. The altitude gage reads 300 feet when the pump is off and 250 feet when the pump has run for several minutes at 450 gpm. What are the static and pumping water levels, respectively?

a. 300 feet/350 feet
b. 600 feet/650 feet
c. 350 feet/300 feet
d. 450 feet/150 feet

____ 7. Given a static pumping level of 75 feet, a pumping water level of 465 feet, and a pump which delivers 250 gpm, what is the specific capacity?

a. .64 gpm/ft.
b. 1.00 gpm/ft.
c. 1.56 gpm/ft.
d. none of the above

____ 8. Your well house water meter reads 69,740 gallons on Tuesday morning and 79,441 gallons on the following Tuesday morning. What is the average daily pumping?

a. 21,312 gpd
b. 79,441 gpd
c. 1,386 gpd
d. 686 gpd

____ 9. If you are to disinfect a reservoir that holds 448,800 gallons of water, how many pounds of HTH powder (70% chlorine) would you add to obtain a 50 ppm chlorine concentration?

a. 187 pounds
b. 267 pounds
c. 366 pounds
d. none of the above

MATCH the following:

____ 10. 1,000 milliliters
____ 11. L x W
____ 12. 8.34 pounds
____ 13. ppm
____ 14. 2.95×10^3
____ 15. 10 millimeters

a. mg/l
b. 1 centimeter
c. 1 liter
d. area of rectangle
e. 1 gallon of water
f. 295,000
g. area of circle
h. 1 decimeter
i. cubic foot of water
j. 2,950

ANSWERS TO STUDENT SELF-CHECK

1. c	9. b
2. c	10. c
3. a	11. d
4. c	12. e
5. b	13. a
6. a	14. j
7. a	15. b
8. c	

FINAL CHECKOUT

	YES	NO
1. Described the metric system by matching prefixes with correct units of length, area, weight (mass), and volume.	___	___
2. Identified metric units commonly used in waterworks field.	___	___
3. Defined given terms.	___	___
4. Identified English units of measurement for given parameters.	___	___
5. Matched algebraic and geometric formulas with correct definitions.	___	___
6. Explained and demonstrated the use of scientific notation and significant figures.	___	___
7. Solved typical waterworks math problems.	___	___

DISTRIBUTION SYSTEMS

Introduction:

The distribution system is made up of water mains, valves, hydrants, service connections, booster pumps, and storage tanks. These components are the means through which water is delivered to the consumer.

Although the distribution system is the least visible part of a waterworks, it is just as important as either the source of supply or the treatment facility. This is evident when one considers that often fifty percent or more of the total waterworks investment is tied up in the distribution system.

The function of the distribution system is to deliver water which is both aesthetically pleasing and bacteriologically safe to meet all consumer needs while maintaining adequate pressure. In order to provide water to consumers at all times, the distribution system with all its component parts must be properly designed to carry the maximum instantaneous flow of a community. Adequate design and proper facilities will not do the job alone. The waterworks must have operators who are familiar with the system and capable of maintaining and expanding it whenever necessary. This module looks at the various parts of a distribution system and common methods of installation in an effort to familiarize introductory operators with a distribution system so they can maintain and expand the system as needed to provide safe, aesthetically pleasing water.

Objectives:

1. IDENTIFY two purposes of the distribution system.
2. LIST the major parts of a distribution system.
3. DESCRIBE considerations in planning a distribution system.
4. LIST factors which determine flow.
5. DESCRIBE properties of the following types of pipe: ductile iron, cast iron, asbestos-cement, plastic, steel, reinforced concrete.
6. EXPLAIN properties of the following types of joints: push-on, mechanical, flange.

Objectives (continued):

7. EXPLAIN the functions of the following pipe fittings: cross, bend, tee, reducer, offset.
8. DESCRIBE considerations of pipe type with respect to soil type.
9. IDENTIFY the frost depth for given sections in Wisconsin.
10. RANK cost of excavation in various types of materials as to most expensive and least expensive.
11. DISCUSS cost of installation of pipe in urban areas versus rural areas.
12. CITE literature available on installation of pipe.
13. EXPLAIN accepted water main installation procedures with respect to: unloading pipe, storage of pipe, trenching, trench shoring, bedding, pipe laying, bending of pipe.
14. EXPLAIN proper methods of making push-on and mechanical joints.
15. EXPLAIN the need for maintaining electrical continuity in metallic pipe and LIST methods by which continuity is established.
16. EXPLAIN installation methods in regard to the following applications: under railroad tracks, river crossing.
17. DESCRIBE properties and use of gate valves.
18. DESCRIBE properties and use of butterfly valves.
19. EXPLAIN accepted water main installation procedures for gate and butterfly valves.
20. EXPLAIN the purpose of a valve box.
21. DISCUSS properties of cast iron versus plastic valve boxes.
22. EXPLAIN the need to exercise valves periodically.
23. EXPLAIN how to determine whether a valve is open or closed.
24. EXPLAIN what happens if valves are closed too fast.

Objectives (continued):

25. IDENTIFY the basic elements of a fire hydrant.
26. DESCRIBE how a fire hydrant works.
27. DESCRIBE correct methods of maintaining hydrants with respect to: weep holes, operating nut, caps and chains.
28. STATE minimum fire flow pressure.
29. IDENTIFY locations where thrust blocks and tie rods should be used.
30. DESCRIBE the properties of the following materials used for water services: type "K" copper, plastic, cast iron.
31. DESCRIBE the properties and use of a corporation stop.
32. DESCRIBE the properties and use of a curb stop.
33. EXPLAIN the purpose of a "Gooseneck" on a service line.
34. IDENTIFY locations where taps are made on mains.
35. DESCRIBE how to tap a water main.
36. EXPLAIN why water mains are tapped under pressure.
37. MAKE a sketch and LABEL all parts of a typical service from the main to a customer's meter.
38. LIST steps taken before a new main is placed in service.
39. IDENTIFY requirements for disinfecting new mains.
40. LIST two purposes for the storage of potable water in tanks.
41. DIFFERENTIATE between ground storage, elevated tanks, and standpipes.
42. DISCUSS the importance of water movement in storage tanks during the winter.
43. LIST two ways steel storage tanks can be protected from corrosion.
44. IDENTIFY two qualities required of paint that will be in contact with potable water.

Objectives (continued):

45. DISCUSS the theory of cathodic protection.

46. IDENTIFY desirable and tolerable static water pressure.

47. DESCRIBE problems associated with high pressure and low pressure.

48. IDENTIFY possible causes of the following pipe breaks: horizontal cracks, joint leaks, blow outs.

49. IDENTIFY methods to determine main breaks.

50. LIST instruments used to locate valves and mains.

51. DESCRIBE methods to repair leaky or broken water mains.

52. DESCRIBE various types of pipe cutters and LIST an application for each.

53. IDENTIFY one way to stop water flow in a copper service so a leaking curb stop can be fixed.

54. EXPLAIN the importance of having adequate cover for water services.

55. EXPLAIN how to thaw non-metallic water services.

56. EXPLAIN how to thaw metallic water services.

57. DESCRIBE the hazards associated with thawing metallic water mains with electricity.

58. DESCRIBE two methods of cleaning encrusted water mains.

59. LIST records a waterworks should keep in regard to its distribution system.

60. EXPLAIN the use and importance of records in locating valves or mains.

Learning Activities:

1. READ AWWA Manual M8, Water Distribution Training Course, Chapters 1, 2, 4, 5, 6, and 8.
2. LISTEN to distribution systems presentation.
3. VIEW AWWA Wisconsin Section Distribution Slide Show.
4. VIEW City of Madison fire hydrant maintenance video tape.
5. EXAMINE Instructor's sample equipment.
6. EXAMINE equipment during field trip.
7. READ Cast Iron Pipe Research Association pamphlet, "A Guide for the Installation of Ductile Iron Pipe."
8. COMPLETE Worksheet.
9. COMPLETE Student Self-check and CHECK answers.
10. PROCEED to Final Checkout.

WORKSHEET

1. What are the two primary functions of the distribution system?

   (1) _____

   _____

   (2) _____

   _____

2. List the major parts of a distribution system.

   _____

   _____

   _____

   _____

   _____

3. What items should be considered in the planning stages of a distribution system prior to trenching and laying pipe?

   _____

   _____

   _____

   _____

4. What factors determine the flow in a section of pipe?

   _____

   _____

   _____

   _____

5. For each of the following types of pipe, explain its properties and identify advantages and disadvantages of each.

ductile iron _____

_____

_____

_____

cast iron _____

_____

_____

_____

asbestos-cement _____

_____

_____

_____

plastic _____

_____

_____

_____

steel _____

_____

_____

_____

reinforced concrete _____

_____

_____

_____

6. Explain how each of the following joints are made.

push-on _____

_____

_____

mechanical _____

_____

_____

flange _____

_____

_____

7. What is the purpose of each of the following pipe fittings?

crosses _____

_____

_____

bends _____

_____

_____

tees _____

_____

_____

reducers _____

_____

_____

offsets _____

_____

_____

8. What effect does acidic soil have on the following types of pipe?

steel _____

_____

ductile iron _____

_____

plastic _____

_____

asbestos-cement _____

_____

9. What steps can be taken to prevent degradation of pipe due to soil acidity?

_____

_____

_____

10. What is the frost depth for Wisconsin in feet and in meters?

	Feet	Meters
Northern Wisconsin	____	____
Southern Wisconsin	____	____

11. Rank the cost of excavation in the three following materials as to most expensive, middle and least expensive.

Material	Rank
rock	_____
water	_____
soil	_____

209

12. Is it more expensive to install water main in urban areas or rural areas? Why?

13. List two additional sources of information (other than your textbook) on the installation of water mains.

14. Explain, in your own words, the correct procedure or method for each of the following:

unloading pipe

storage of pipe

trenching

shoring

15. What are the more common pieces of equipment used today for digging a trench?

16. Under what conditions is trench shoring necessary?

17. List three soils which generally require shoring.

18. What is meant by bedding?

19. Where is bedding used?

20. Describe, in your own words, the correct method for laying pipe in a trench.

21. Must pipe be layed perfectly straight or can it be bent or deflected somewhat?

23. In your own words, describe the proper method of assembling the following joints:

push-on _____

_____

_____

_____

mechanical _____

_____

_____

_____

24. Why is it necessary to maintain electrical continuity in pipes?

_____

_____

25. What methods are available for maintaining electrical continuity?

_____

_____

_____

26. What precautions or special considerations must be made when installing pipe under railroad tracks or in rivers?

railroads _____

_____

_____

rivers _____

_____

_____

27. In your own words, explain what a gate valve is and how it works.

28. In your own words, explain what a butterfly valve is and how it works.

29. Describe the installation procedures for gate and butterfly valves.

30. If you were the manager of a waterworks, which type of valve would you install? Why would you install it?

31. What is a valve box?

32. What is the purpose of a valve box?

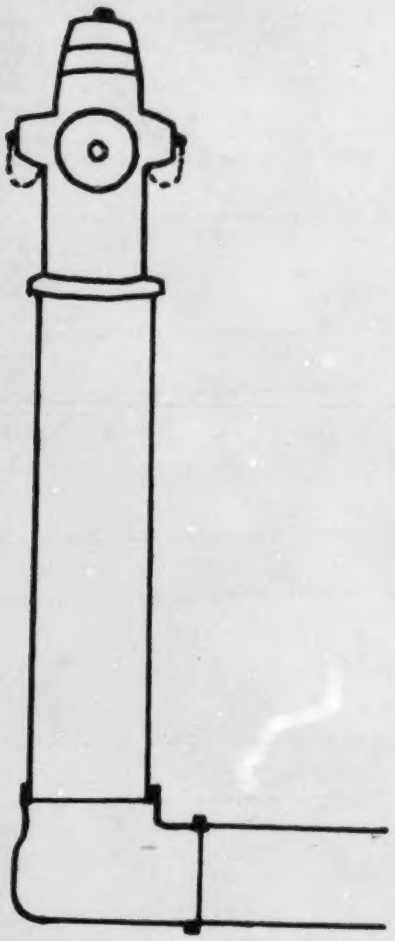
33. Compare and contrast cast iron versus plastic valve boxes.

34. Why must valves be exercised periodically?

36. How can you tell if a valve is open or closed?

37. What happens if a valve is closed too fast?

38. In the following sketch, identify the three basic sections of a fire hydrant.



39. In your own words, describe how a fire hydrant works.

40. Describe the correct maintenance procedures for your system's fire hydrants in regard to the following.

weep holes _____

_____

_____

operating nut _____

_____

_____

chains and caps _____

_____

_____

48. What is a corporation stop and where is it found?

_____

_____

49. Explain, in your own words, the purpose for a corporation stop.

_____

_____

_____

50. What is a curb stop and where is it found?

_____

_____

51. Again, in your own words, explain the function of a curb stop.

_____

_____

_____

52. What is the purpose of putting a "gooseneck" in a service line?

_____

_____

53. Locate on the main below the correct location(s) to make a stop.

54. Describe, in your own words, how to tap a water main.

_____

_____

_____

_____

_____

_____

55. Why are water mains tapped under pressure?

_____

_____

56. Draw a diagram, labeling all parts, of a typical service from the water main to a customer meter.

57. List four steps to be completed before a new main is placed in service and sequence this as to first and last.

first _____

_____

_____

last _____

58. What are the Wisconsin DNR requirements for disinfecting new water mains?

_____

_____

_____

59. What are two purposes for storing potable water in tanks or reservoirs?

_____

_____

60. Differentiate between ground storage, elevated tanks and standpipes.

_____

_____

_____

_____

61. Why is it important the water levels be fluctuated during the winter in cold climate storage tanks?

_____

62. What are two ways to protect steel storage tanks from corrosion?

_____

_____

63. What are two qualities or requirements of paint that will be in contact with potable water?

_____

_____

64. Explain, in your own words, how cathodic protection works.

_____

_____

_____

65. What are desirable and tolerable static water pressures?

desirable _____

tolerable _____

66. What are some possible causes for the following types of leaks?

horizontal crack _____

_____

joint leak _____

_____

blow out _____

_____

67. What are some of the more common methods or instruments used to find a main break?

_____

_____

_____

_____

68. What instruments are used to locate mains and valve boxes?

_____

_____

69. Describe, in your own words, how to repair a cracked main using a sleeve.

_____

_____

_____

_____

_____

70. List three types of pipe cutters and the type(s) of pipe each can be used on.

Cutter	Type of Pipe

71. What are two ways to stop flow in a copper service so a leaky curb stop can be fixed?

72. Why is it important that water services have adequate cover?

73. List some methods to thaw metallic services.

74. List some methods to thaw non-metallic services.

75. What are some of the hazards associated with thawing metallic pipe with electricity (arc-welder)?

76. List two methods used to clean encrusted water mains.

77. Describe how each of the aforementioned methods works.

78. What records should a waterworks keep for its distribution system?

79. Why is it necessary to keep distribution system records?

STUDENT SELF-CHECK

____ 1. Communities located near a fault or in areas prone to earthquakes would most likely install what type of pipe for their distribution system?

a. concrete
b. asbestos cement
c. ductile iron
d. clay

____ 2. Ideally, valves should be exercised at least:

a. once a week
b. once a month
c. once a year
d. valves do not need to be exercised

____ 3. Minimum required fire flow pressure is:

a. 10 psi
b. 20 psi
c. 30 psi
d. 35 psi

____ 4. Water hammer results from:

a. closing valves too fast
b. not tapping mains under pressure
c. poor disinfection methods
d. acidic soil conditions

____ 5. Steel storage tanks can be protected from corrosion by:

a. painting
b. fluctuating water levels
c. addition of chlorine
d. cathodic protection
e. b and c
f. a and d

___ 6. Which one of the following is not a suitable material for thrust blocks?

a. concrete
b. hardwood
c. stone
d. PVC

___ 7. Which of the following soils generally require shoring?

a. sand
b. loam
c. loosely bound clay
d. all of the above

___ 8. A dip needle is commonly used to locate what?

a. break in a water main
b. metallic valve box
c. leaky copper service
d. plastic water main

___ 9. Service taps are most often made at _____ and _____ on a water main.

a. 10 o'clock and 2 o'clock
b. 12 o'clock and 6 o'clock
c. 10 o'clock and 4 o'clock
d. 4 o'clock and 8 o'clock

___ 10. Which of the following is a suitable method for maintaining electrical continuity?

a. conductive cables
b. metal wedges
c. metal tipped gaskets
d. all of the above

___ 11. All of the following are items to be checked on a hydrant inspection except:

a. drainage
b. condition of caps, chains and operating nut
c. bell joint
d. leaks

____ 12. A distribution system using butterfly valves can easily be cleaned using a "poly pig." TRUE or FALSE?

____ 13. Under certain conditions pipe can be pushed off the bank and allowed to fall into the trench. TRUE or FALSE?

____ 14. High system pressure (greater than 100) tends to aggravate leak problems. TRUE or FALSE?

ANSWERS TO STUDENT SELF-CHECK

1. c
2. c
3. b
4. a
5. f
6. d
7. d
8. b
9. a
10. d
11. c
12. FALSE
13. FALSE
14. TRUE

FINAL CHECKOUT

		YES	NO
1.	Identified two purposes of the distribution system.	___	___
2.	Listed the major parts of a distribution system.	___	___
3.	Described considerations in planning a distribution system.	___	___
4.	Listed factors which determine flow.	___	___
5.	Described properties of the following types of pipe: ductile iron, cast iron, asbestos-cement, plastic, steel and reinforced concrete.	___	___
6.	Explained properties of the following types of joints: push-on, mechanical, flange.	___	___
7.	Explained the functions of the following pipe fittings: cross, bend, tee, reducer, offset.	___	___
8.	Described considerations of pipe type with respect to soil type.	___	___
9.	Identified the frost depth for given sections of Wisconsin.	___	___
10.	Ranked cost of excavation in various types of material as to most expensive and least expensive.	___	___
11.	Discussed cost of installation of pipe in urban areas versus rural areas.	___	___

		YES	NO
12.	Cited literature available on installation of pipe.	___	___
13.	Explained accepted water main installation procedures with respect to: unloading pipe, storage of pipe, trenching, trench shoring, bedding, pipe laying, bending of pipe.	___	___
14.	Explained proper methods of making push-on and mechanical joints.	___	___
15.	Explained the need for maintaining electrical continuity in metallic pipe and listed methods by which continuity is established.	___	___
16.	Explained installation methods in regard to the following applications: under railroad tracks, river crossing.	___	___
17.	Described properties and use of gate valves.	___	___
18.	Described properties and use of butterfly valves.	___	___
19.	Explained accepted water main installation procedures for gate and butterfly valves.	___	___
20.	Explained the purpose of a valve box.	___	___
21.	Discussed properties of cast iron versus plastic valve box.	___	___
22.	Explained the need to exercise valves periodically.	___	___
23.	Explained how to determine whether a valve is open or closed.	___	___
24.	Explained what happens if valves are closed too fast.	___	___
25.	Identified the basic elements of a fire hydrant.	___	___
26.	Described how a fire hydrant works.	___	___
27.	Described correct methods of maintaining hydrants with respect to: weep holes, operating nut, caps and chains.	___	___
28.	Stated minimum fire flow pressure.	___	___
29.	Identified locations where thrust blocks and tie rods should be used.	___	___
30.	Described the properties of the following materials used for water services: type "K" copper, plastic, cast iron.	___	___

		YES	NO
31.	Described the properties and use of a corporation stop.	___	___
32.	Described the properties and use of a curb stop.	___	___
33.	Explained the purpose of a "Gooseneck" in a service line.	___	___
34.	Identified locations where mains are tapped.	___	___
35.	Described how to tap a water main.	___	___
36.	Explained why water mains are tapped under pressure.	___	___
37.	Made a sketch and labeled all parts of a typical service from the main to a customer's meter.	___	___
38.	Listed steps taken before a new main is placed in service.	___	___
39.	Identified requirements for disinfecting new mains.	___	___
40.	Listed two purposes for the storage of potable water in tanks.	___	___
41.	Differentiated between ground storage, elevated tanks, and standpipes.	___	___
42.	Discussed the importance of water movement in storage tanks during the winter.	___	___
43.	Listed two ways steel storage tanks can be protected from corrosion.	___	___
44.	Identified two qualities required of paint that will be in contact with potable water.	___	___
45.	Discussed the theory of cathodic protection.	___	___
46.	Identified desirable and tolerable static water pressure.	___	___
47.	Described problems associated with high pressure and low pressure.	___	___
48.	Identified possible causes of the following pipe breaks: horizontal cracks, joint leaks, blow outs.	___	___
49.	Identified methods to determine main breaks.	___	___
50.	Listed instruments used to locate valves and mains.	___	___

		YES	NO
51.	Described methods to repair leaky or broken water mains.	___	___
52.	Described various types of pipe cutters and listed an application for each.	___	___
53.	Identified one way to stop water flow in a copper service so a leaking curb stop can be fixed.	___	___
54.	Explained the importance of having adequate cover for water services.	___	___
55.	Explained how to thaw non-metallic water pipes.	___	___
56.	Explained how to thaw metallic water pipes.	___	___
57.	Described the hazards associated with thawing metallic water mains with electricity.	___	___
58.	Described two methods of cleaning encrusted water mains.	___	___
59.	Listed records a waterworks should keep in regard to its distribution system.	___	___
60.	Explained the use and importance of records in locating valves or mains.	___	___

METERS

Introduction:

Accurate water measurement through metering is a key point in the operation of any waterworks. The water meter enables utilities, municipalities, and sanitary districts to deal justly and impartially with all by compelling each customer to pay for the exact amount of water used. The use of a water meter is not only an equitable way to charge customers, but it is also a tool for conserving current water supplies making every customer a self-interested guardian of the water supply.

The evolution of the water meter dates back some 3,000 years to North Africa. Since that time the water meter has undergone radical changes to a point where there are now various types of water meters for different applications. The most notable meters in use today are positive displacement meters (oscillating piston and nutating disk), compound meters, current meters (turbine and propeller), and proportional meters.

One must be aware that meters should not be placed into service and forgotten until they fail. Periodic maintenance and testing are necessary if a successful program is desired.

This module discusses the various types of meters, their function and upkeep.

Objectives:

1. LIST three reasons for metering water.
2. EXPLAIN the effect metering has on consumption.
3. LIST four types of meters.
4. DESCRIBE the operation of the type of positive displacement meter your facility uses and LIST an application of it.
5. DISASSEMBLE a positive displacement meter and IDENTIFY the various parts.
6. DESCRIBE the function of the frost plate on a positive displacement meter and IDENTIFY its composition.

Objectives (continued):

7. DESCRIBE the operation of a compound meter and IDENTIFY an application of it.
8. DESCRIBE the operation of a turbine meter and IDENTIFY an application of it.
9. LIST three factors which must be considered in selecting the correct size meter.
10. LIST several considerations involved in the location of a meter.
11. DISCUSS electrical continuity in relation to plastic water meters and to removal of a water meter from its setting.
12. Given examples of different types of meter dial faces, DEMONSTRATE ability to correctly read meter.
13. DISCUSS problems of lockouts and GIVE examples of how to minimize the problem or compensate for it.
14. IDENTIFY reasons for and advantages of installing romote readers.
15. EXPLAIN Wisconsin Public Service Commission requirements for meter testing.
16. IDENTIFY methods for cleaning various types of meters.
17. EXPLAIN what is involved in a meter test bench operation.
18. LIST three items to record on meter test card for good meter maintenance.

Learning Activities:

1. READ Chapter 7, AWWA Manual M8.
2. LISTEN to presentation on meters.
3. EXAMINE and READ handout material.
4. EXAMINE sample meters.
5. DISASSEMBLE sample meters or meters in your shop.

Learning Activities
(continued):

6. COMPLETE Worksheet.

7. LOCATE meter records at your facility.

8. COMPLETE Student Self-check and CHECK answers.

9. PROCEED to Final Checkout.

WORKSHEET

1. List three reasons why water should be metered.

   (1) _____

   (2) _____

   (3) _____

2. What effect does metering have on the consumption or use of water?

   _____

   _____

3. List four types of meters.

   (1) _____

   (2) _____

   (3) _____

   (4) _____

4. In your own words, describe how a positive displacement meter (either nutating disk or oscillating piston) works.

   _____

   _____

   _____

   _____

   _____

5. What is the most common application for a positive displacement meter?

   _____

   _____

6. At your meter shop, disassemble a positive displacement meter and in the space below, sketch the various parts, labeling each part.

7. What is the purpose of having a frost plate on the bottom of a positive displacement meter?

_____

_____

_____

8. Frost plates are generally made out of what?

_____

9. In your own words, describe how a compound meter works.

10. Compound meters function best under what type of conditions?

11. Where would you most likely find a compound meter in use?

12. Again, in your own words, describe how a turbine meter works.

13. Turbine meters function best under what type of conditions?

14. Where might a turbine meter be used?

15. What factors come into play when sizing a meter?

16. A meter cannot be placed just anywhere. What points should a waterworks operator consider when installing a meter?

17. Is electrical continuity important in relation to plastic meters? If so, why?

18. Is electrical continuity important when removing a meter from its setting? If so, why?

19. Describe some problems you have encountered on your meter readings.

20. What have you done to minimize these problems or compensate for them?

21. What are some of the advantages of remote reading devices?

_____

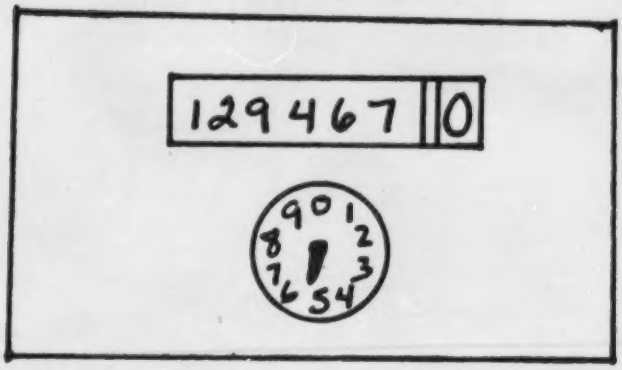
_____

_____

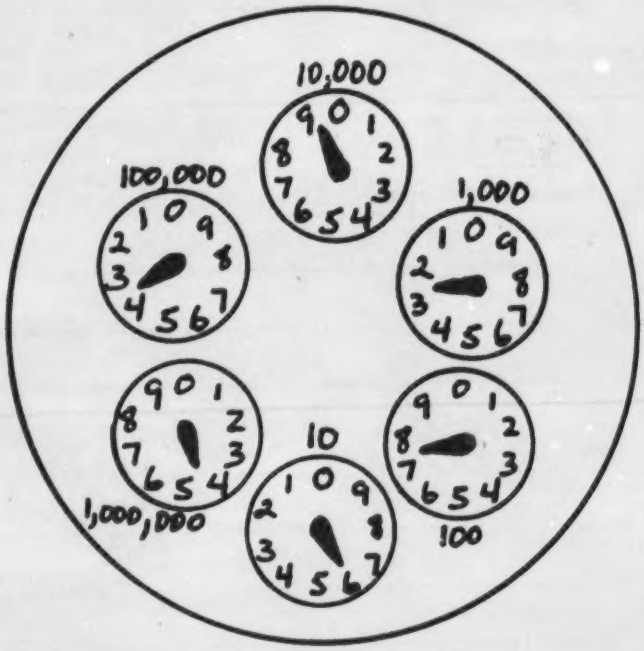
_____

_____

22. Read the following meter dials.



_____



_____

237

23. Customer meters must be tested before use, upon request or customer complaint, and periodically to insure accuracy. The test intervals (in years) for the following size meters are:

Size	Test Interval (years)
5/8"	_____
1"	_____
2"	_____
6"	_____

24. Identify the minimum test flow and the normal test flow limits for the following positive displacement meters.

Meter Size	Minimum Test Flow (gpm)	Normal Test Flow Limit (gpm)
5/8"	_____	_____
1"	_____	_____

25. How is an encrusted metal meter cleaned?

_____

_____

_____

26. What safety precautions should one observe when cleaning a metal meter?

_____

_____

_____

27. How is a plastic meter cleaned?

_____

_____

_____

28. In your own words, describe how to test a meter on a meter test bench.

_____

_____

_____

_____

_____

29. What are three items that should be recorded on a meter maintenance card?

(1) _____

(2) _____

(3) _____

_____

STUDENT SELF-CHECK

___ 1. The "heart" or "guts" of a positive displacement meter is the:

a. register
b. chamber
c. thrust pin
d. screen

___ 2. Compound meters are generally used in all the following <u>except</u>:

a. apartments
b. schools
c. small industries
d. private homes

___ 3. In northern climates, the part of a meter most likely to be damaged if the meter freezes is:

a. register
b. frost bottom
c. chamber
d. screen

___ 4. All of the following are important to record on a meter maintenance card <u>except</u>:

a. reading as found
b. percent registration as found
c. serial number
d. time meter sits in shop

___ 5. All of the following are reasons to meter water <u>except</u>:

a. reduce water consumption
b. better management - know where water is going
c. collect revenue
d. reduce maintenance time

___ 6. A turbine meter has all of the following <u>except</u>:

a. trouble with accuracy on constant high flows
b. very little headloss
c. reduced accuracy on low flows
d. less weight than a compound meter of same size

___ 7. Not maintaining a meter maintenance program generally results in inaccurate registration. TRUE or FALSE?

____ 8. When installing a plastic meter, it is necessary to attach a grounding strap to insure continuity. TRUE or FALSE?

____ 9. Positive displacement meters are almost always used in residential buildings. TRUE or FALSE?

____ 10. Plastic meters should always be cleaned by dumping in a sulfuric acid solution. TRUE or FALSE?

ANSWERS TO STUDENT SELF-CHECK

1. b
2. d
3. b
4. d
5. d
6. a
7. TRUE
8. TRUE
9. TRUE
10. FALSE

FINAL CHECKOUT

	YES	NO
1. Listed three reasons for metering water.	___	___
2. Described the effect metering has on consumption.	___	___
3. Listed four types of meters.	___	___
4. Described the operation of a positive displacement meter and listed an application of it.	___	___
5. Disassembled a positive displacement meter and identified the various parts.	___	___
6. Described the function of a frost plate on a positive displacement meter and identified its composition.	___	___
7. Described the operation of a compound meter and identified an application of it.	___	___
8. Described the operation of a turbine meter and listed an application of it.	___	___
9. Listed three factors which must be considered in selecting the correct size meter.	___	___
10. Listed considerations involved in the location of a meter.	___	___
11. Discussed electrical continuity in relation to plastic water meters and when removing a water meter from its setting.	___	___

12.	Demonstrated ability to correctly read various types of meter dial faces.	___	___
13.	Discussed problems of lockouts and gave examples of how to minimize the problem or compensate for it.	___	___
14.	Identified reasons for and advantages of installing remote readers.	___	___
15.	Explained Wisconsin PSC requirements for meter testing.	___	___
16.	Identified methods for cleaning various types of meters.	___	___
17.	Explained meter test bench operations.	___	___
18.	Listed three items to record on meter test card for good meter maintenance.	___	___

CROSS CONNECTIONS

Introduction:

Cross connections link potable (drinking) water to non-potable (contaminated or questionable safety) water. Contamination enters the potable water supply when there is a reversal of flow in the system caused by back-siphonage or backpressure backflow. Backsiphonage or backpressure backflow arises under a variety of circumstances, some of which will be discussed in this module. Cross connections pose serious public health hazards and are ever present dangers because piping system are continually being installed, altered, or extended.

Cross connections appear in many subtle forms and unsuspected places. Reversal of pressure--leading to backflow or backsiphonage--may be freakish and unpredictable. The purpose of this module is to define, describe, and illustrate typical cross connections, and to suggest simple methods and devices by which they may be eliminated in order to ensure the distribution of safe, sanitary drinking water.

Objectives:

1. DEFINE cross connection.
2. LIST the more common types of cross connections.
3. EXPLAIN the term backflow.
4. DESCRIBE conditions that can cause backflow.
5. EXPLAIN the term backsiphonage.
6. DESCRIBE conditions which can cause backsiphonage.
7. LIST five devices for controlling cross connections, EXPLAIN how each works, and IDENTIFY an application for each.
8. STATE how often cross connection control devices need to be checked.
9. EXPLAIN what a cross connection control program is.
10. DESCRIBE a program for controlling cross connections.

Learning Activities:

1. READ page 68, AWWA Manual M8, Cross Connection Control.
2. VIEW film, "Water, Water Everywhere."
3. EXAMINE sample cross connection control devices.
4. READ "50 Cross Connection Questions, Answers and Illustrations" pamphlet.
5. COMPLETE Worksheet.
6. COMPLETE Student Self-check and CHECK answers.
7. PROCEED to Final Checkout.

WORKSHEET

1. What is a cross connection?

2. List three common cross connections.

   (1)

   (2)

   (3)

3. What is meant by the term backflow? (Explain in relation to cross connections.)

4. What factors can cause backflow?

5. In relation to cross connections, what is meant by the term backsiphonage?

6. What factors can cause backsiphonage?

7. There are a variety of devices on the market for controlling cross connections. List five below.

(1) _____

(2) _____

(3) _____

(4) _____

(5) _____

8. Explain how each device listed above works.

(1) _____

(2) _____

(3) _____

(4) _____

(5) _____

9. Identify an application (where you could use it) for each cross connection control device listed in Question #7.

Device	Application

10. What is the purpose of a strainer preceding a backflow preventer?

11. How often does a reduced pressure backflow preventer need to be inspected and tested?

12. What is a cross connection control program?

13. Describe the cross connection control program at your waterworks. (If your facility doesn't have such a program, describe one you would implement.)

_____

_____

_____

_____

_____

_____

STUDENT SELF-CHECK

____ 1. _____ link potable water with non-potable water.

a. Indirect service lines
b. Backflow preventers
c. Cross connections
d. Pressure gages

____ 2. Which of the following is <u>not</u> a cross connection control device?

a. air gap
b. vacuum breaker
c. double check valve
d. sill cock

____ 3. Two factors which are essential for backsiphonage are:

a. link between systems, negative pressure
b. link between systems, increase in downstream pressure
c. backflow preventer, atmospheric pressure
d. check valve, hydraulic pressure

____ 4. A strainer:

a. purifies non-potable water
b. prevents backsiphonage
c. is a vent for a vacuum breaker
d. protects check valves on RP devices from fowling by debris

____ 5. Reduced pressure backflow preventers must be inspected _____ by someone knowledgeable on their operation and tested _____ by a certified tester.

a. daily, weekly
b. weekly, monthly
c. weekly, yearly
d. monthly, yearly

6. What means of backsiphonage prevention would you use for a submerged inlet in a second-floor bathtub?

_____

7. What backflow prevention device is typically installed for laboratory sinks?

---

8. Can an atmospheric vacuum breaker be used under continuous pressure?

---

9. OSHA requires that no cross connection be allowed in an installation unless it is properly protected with an approved backflow prevention device. TRUE or FALSE?

10. All municipal waterworks should have a cross connection control program to eliminate present cross connections and to prevent future ones. TRUE or FALSE?

ANSWERS TO STUDENT SELF-CHECK

1. c
2. d
3. a
4. d
5. c
6. air gap
7. vacuum breaker
8. no
9. TRUE
10. TRUE

FINAL CHECKOUT

		YES	NO
1.	Defined cross connection.	___	___
2.	Listed the more common types of cross connections.	___	___
3.	Explained backflow.	___	___
4.	Described conditions that can cause backflow.	___	___
5.	Explained backsiphonage.	___	___
6.	Described conditions which can cause backsiphonage.	___	___
7.	Listed five devices for controlling cross connections, explained how each works, and identified an application for each.	___	___
8.	Stated how often cross connection control devices need to be checked.	___	___
9.	Explained what a cross connection control program is.	___	___
10.	Described program for controlling cross connections.	___	___

SAFETY

Introduction:

Safety of the waterworks operator has long been overlooked at most facilities and is only coming into its own today. Operators are still being injured, maimed, and even killed at an alarming rate. This module promotes the idea that safety should be an integral part of every water utility's operation. People can work safely when they know how to do their jobs properly and have a safe place in which to work.

Objectives:

1. DISCUSS frequency of accidents sustained by water supply workers compared to gas and electric workers.

2. IDENTIFY responsibilities employers and employees must assume if accidents are to be prevented.

3. IDENTIFY who is in charge of employee safety for your facility or community.

4. DISCUSS the formation of a safety committee in relation to:

   a. benefits of the safety committee
   b. size of the safety committee
   c. chairperson of the safety committee
   d. frequency of meetings
   e. subject area of meetings
   f. terms of membership

5. IDENTIFY what injury records your facility maintains and where they are located.

6. IDENTIFY accident prone situations for waterworks employees.

7. DESCRIBE the correct way to lift a heavy object.

8. DESCRIBE proper clothing for waterworks operators.

9. IDENTIFY when a waterworks operator needs face and eye protection.

10. IDENTIFY forms of face and eye protection at your plant and where they are located.

11. LIST the types of safety gloves available and DESCRIBE an application for each.

Objectives (continued):

12. STATE where safety gloves are kept at your facility.
13. LIST the types of hard hats available and DESCRIBE an application for each.
14. STATE where hard hats are kept at your facility.
15. IDENTIFY where safety belts are used in the waterworks field.
16. LIST the types of respiratory equipment available and DESCRIBE the limitations of each.
17. DESCRIBE safety precautions for handling waterworks chemicals.
18. LIST tasks which should be completed before entering a manhole.
19. REVIEW safe trenching practices.
20. IDENTIFY where first aid training and CPR training are available in your community.
21. IDENTIFY the State agency responsible for enforcing safe working conditions in waterworks plants.

Learning Activities:

1. READ Chapter 11, AWWA Manual M18.
2. LISTEN to presentation on waterworks safety.
3. READ "Excavating and Trenching Operations," pamphlet.
4. LOCATE and STUDY information on accident types and frequency.
5. COMPLETE Worksheet.
6. COMPLETE Student Self-check and CHECK answers.
7. PROCEED to Final Checkout.

WORKSHEET

1. Which group (as a whole) sustains a greater percentage of accidents: gas and electric workers or water supply workers? What is the ratio between the two?

2. Employees and employers must assume five responsibilities if accidents are to be prevented. List these.

   (1)

   (2)

   (3)

   (4)

   (5)

3. Who is in charge of employee safety for your facility or community?

4. Give your ideas on the following:

   a. benefits a utility might realize from the formation of a safety committee?

   b. size of a safety committee?

c. qualifications of a waterworks safety chairperson?

d. how often a safety committee should meet?

e. subjects a safety committee should discuss?

f. should committee members be rotated? If so, how often?

5. What injury records does your waterworks keep?

6. Where are they located?

7. Where do you feel accidents are most likely to occur at your facility?

8. What can you do to prevent accidents at your facility?

9. Describe the correct way to lift a heavy object.

10. What type of clothing does a safety-conscious waterworks operator wear?

11. List some situations where face and eye protection are needed.

12. What forms of face and eye protection do you keep at your plant? Where are they located?

13. List three types of safety gloves and describe an application (use) for each.

(1) _____ _____

_____

(2) _____ _____

_____

(3) _____ _____

_____

14. Where are the safety gloves at your facility located?

_____

_____

15. List two types of hard hats and describe an application (use) for each.

(1) _____ _____

_____

(2) _____ _____

_____

16. Where are the hard hats kept at your facility?

_____

_____

17. Where might a waterworks operator use a safety belt?

_____

_____

_____

18. List three types of respiratory equipment and describe the limitations of each.

(1) _____ _____

_____

_____

(2) _____ _____

_____

_____

(3) _____ _____

_____

_____

19. What precautions should be observed when handling the chemicals used at your waterworks?

_____

_____

_____

_____

_____

_____

_____

_____

20. What steps should be taken before entering a manhole?

_____

_____

_____

_____

_____

_____

21. Where in your community is first aid and CPR training available?

_____

_____

22. What state agency is responsible for enforcing safe working conditions in waterworks plants?

_____

_____

_____

STUDENT SELF-CHECK

___ 1. Which state agency is responsible for regulation of safe working conditions for municipal workers?

a. DNR
b. Wisconsin Safety Council
c. DILHR
d. Wisconsin Schools of VTAE

___ 2. In which of the following cases is eye protection needed?

a. breaking pavement with an air hammer
b. handling hazardous chemicals
c. operating a drill or lathe
d. all of the above

___ 3. Which would <u>not</u> be worn by a safety-conscious operator?

a. boots with metal toe guards
b. leather palm gloves
c. baggy clothing
d. hard hat

___ 4. One of the most important points in forming a safety committee is:

a. employer support
b. a large committee
c. frequent meetings
d. an articulate chairperson

___ 5. Manholes should never be entered until:

a. one is assured the air is safe
b. barricades and warning signs have been erected
c. a second person is around to insure the buddy system
d. all of the above

___ 6. In a chlorine leak, a canister-type mask would be much safer than an air-pack. TRUE or FALSE?

___ 7. Most lifting accidents are caused not be lifting improperly, but by lifting beyond capacity. TRUE or FALSE?

___ 8. The size of a safety committee should be such that members don't become spectators, but rather such that each member can participate actively. TRUE or FALSE?

___ 9. Metal hard hats should be used when there is an electrical hazard. TRUE or FALSE?

ANSWERS TO STUDENT SELF-CHECK

1. c
2. d
3. c
4. a
5. d
6. FALSE
7. TRUE
8. TRUE
9. FALSE

FINAL CHECKOUT

	YES	NO
1. Discussed accidents sustained by water supply workers compared to gas and electric workers.	___	___
2. Identified responsibilities employers and employees must assume if accidents are to be prevented.	___	___
3. Identified who is in charge of employee safety for your facility or community.	___	___
4. Discussed formation of a safety committee.	___	___
5. Identified what injury records your facility maintains and where they are located.	___	___
6. Identified accident prone situations for waterworks employees.	___	___
7. Described correct way to lift a heavy object.	___	___
8. Described proper clothing for waterworks operators.	___	___
9. Identified when face and eye protection are needed.	___	___
10. Identified forms of face and eye protection and where they are located at own plant.	___	___
11. Listed types of safety gloves available and described an application for each.	___	___
12. Stated where safety gloves are kept at own facility.	___	___

	YES	NO
13. Listed types of hard hats available and described an application for each.	___	___
14. Stated where hard hats are kept at your facility.	___	___
15. Identified where safety belts are used in the waterworks field.	___	___
16. Listed the types of respiratory equipment available and described the limitations of each.	___	___
17. Described safety precautions for handling waterworks chemicals.	___	___
18. Listed tasks which should be completed before entering a manhole.	___	___
19. Reviewed safe trenching practices.	___	___
20. Identified where first aid training and CPR training is available in your community.	___	___
21. Identified the state agency responsible for enforcing safe working conditions in waterworks plants.	___	___